March 11, 1957 50 cents

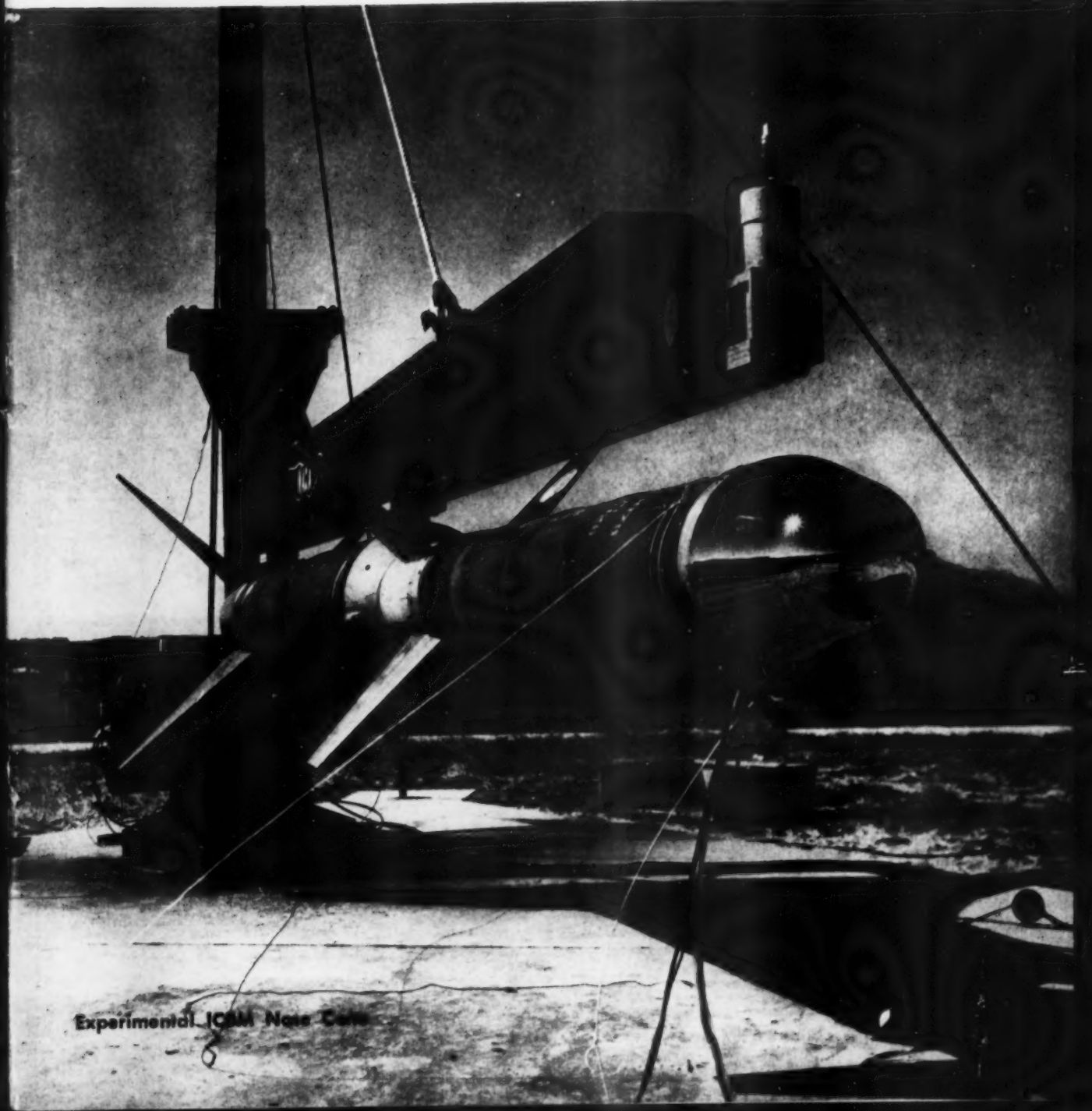
AVIATION WEEK

A McGRAW-HILL PUBLICATION

NACA Gains Data For Manned Rocket

•

Speed, Range Grow In New Aero 560-E



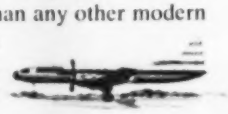
Experimental ICBM Nose Cone

GOING PLACES!

People on the go, go Convairliner... *the world over!*

Forty-one leading airlines on all six continents now offer you the unexcelled convenience, comfort and dependability of the Convairliner. Built-in steps, ample racks for carry-on luggage, and many other comforts that are only now being planned for airliners of the future, are yours to enjoy *today* on a Convair!

No wonder more airlines have chosen the Convair than any other modern passenger plane. Ask your travel agent or favorite airline to make your next flight a Convair. Wherever you go, you'll find a Convair *going places* the world over!



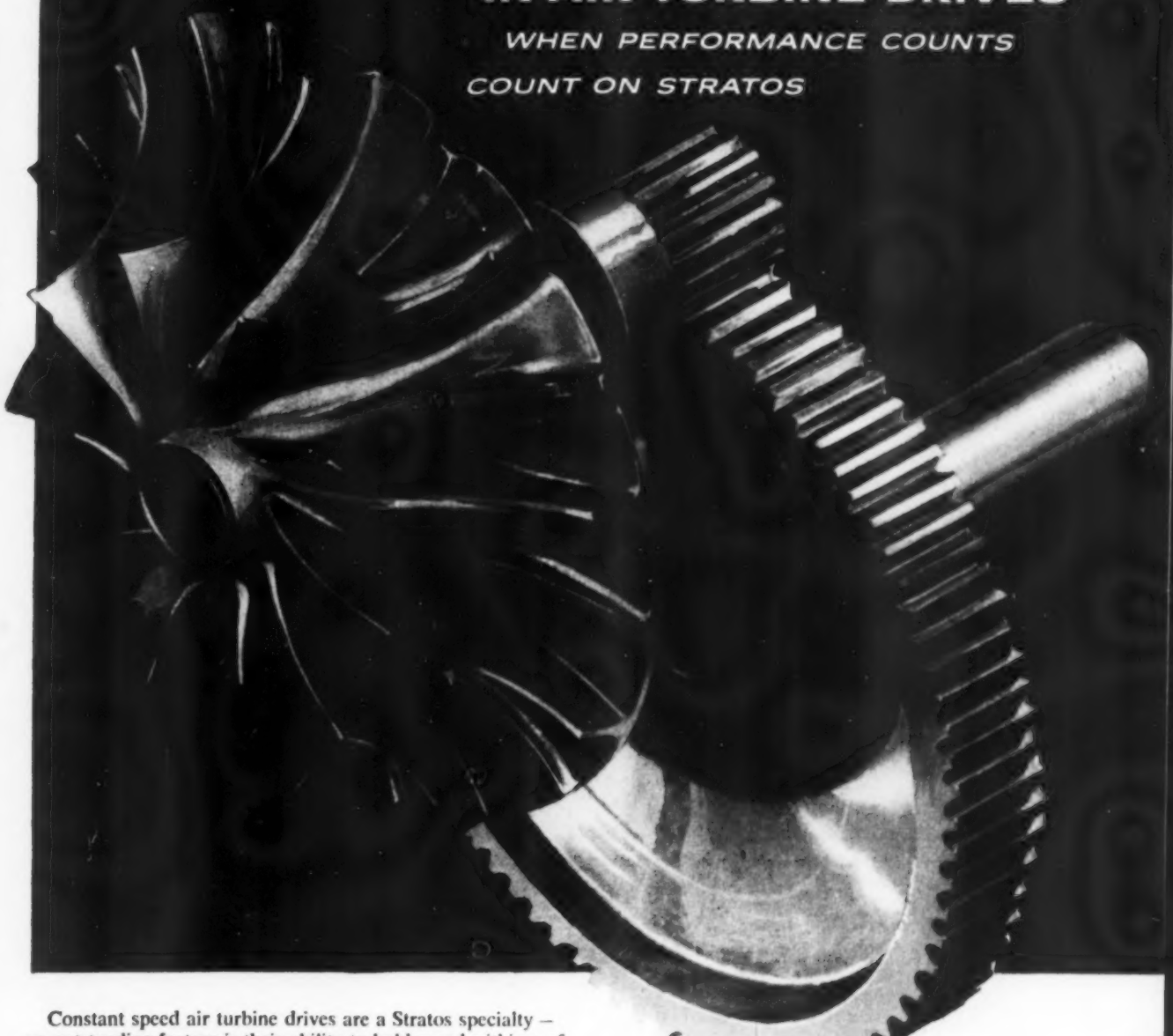
CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION

IN AIR TURBINE DRIVES

WHEN PERFORMANCE COUNTS

COUNT ON STRATOS



Constant speed air turbine drives are a Stratos specialty – an outstanding feature is their ability to hold speed within ± of ¼ of 1% from no load to overload conditions.

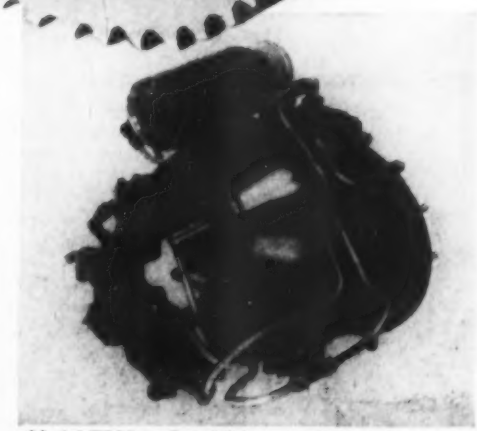
Particularly significant are the safety precautions designed into these rugged units. Besides an inherently sound design, each model incorporates an integral overspeed protection system – independent of the governing system – which shuts down the turbine mechanically. Overspeed trips are of several types – some resettable in flight – so that the best arrangement for each installation can be selected.

For additional information on Stratos' line of air turbine drives, write to:

STRATOS

A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

Main Plant: Bay Shore, L. I., N. Y.
West Coast Office: 1355 Westwood Blvd., Los Angeles, Calif.
Western Branch: 1800 Rosecrans Ave. Manhattan Beach, Calif.



Model TP25-1, for driving a 15 kva alternator

THIN-WALL magnesium casting for the Regulus missile fin produced by Dow.

QUALITY MAGNESIUM CASTINGS

for aircraft and missiles

Sand, Permanent Mold, Plaster Castings

YOU NAME THE CASTING. Dow can supply you with ordinary and extraordinary shapes or sizes. Specialized techniques rigidly maintain your standards and specifications. Heavy-wall or thin-wall, room or elevated temperature use, the best—and surest—answer to your problems is Dow magnesium castings! Contact your nearest Dow sales office for additional information. THE DOW CHEMICAL COMPANY, Foundry Sales, Bay City, Michigan.

YOU CAN DEPEND ON DOW

AVIATION CALENDAR

Mar. 11-15—1957 Atomic Exposition including Nuclear Engineering & Science Congress, 5th Atomic Energy in Industry Conference and 5th Hot Laboratories & Equipment Conference, Convention Hall, Philadelphia, Pa.

Mar. 14—Flight Testing of Very High Performance Aircraft, NACA, Los Angeles.

Mar. 14-15—Flight Propulsion Meeting (Classified), sponsored by IAS, Hotel Carter, Cleveland, Ohio.

Mar. 18-21—Pacific Coast Plastics Exposition, in conjunction with The Society for Plastics Industry, National Conference, Shrine Exposition Hall, Los Angeles.

Mar. 18-21—National Convention, Institute of Radio Engineers, New York Coliseum and Hotel Waldorf-Astoria, New York.

Mar. 18-21—First Military Automation Exposition, New York Trade Show Building, 500 Eighth Ave., New York. For details write: Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Pa.

Mar. 18-21—Second Annual Conference, Gas Turbine Power Division of the American Society of Mechanical Engineers, Hotel Sheraton-Cadillac, Detroit.

Mar. 20—Air Route Traffic Control, Communications Division, American Institute of Electrical Engineers, Engineering Societies Bldg., New York City.

Mar. 23—New England Region American Helicopter Society, General Electric Co., Schenectady, New York. For details write: John E. Ryan, General Electric, Lynn, Mass.

Mar. 25-29—Tenth Western Metal Congress, Ambassador Hotel, Los Angeles.

Mar. 26-28—Sixth Weather Radar Conference, American Meteorological Society, Cambridge, Mass.

Mar. 27-29—Educational Colloquium on Radiation Effects on Materials, sponsored by Office of Naval Research and Glenn L. Martin Co., Johns Hopkins University Baltimore, Md.

Apr. 2-5—National Aeronautic Meeting, Aeronautic Production Forum and Air

(*Continued on page 6*)

AVIATION WEEK • MARCH 11, 1957

Vol. 66, No. 10

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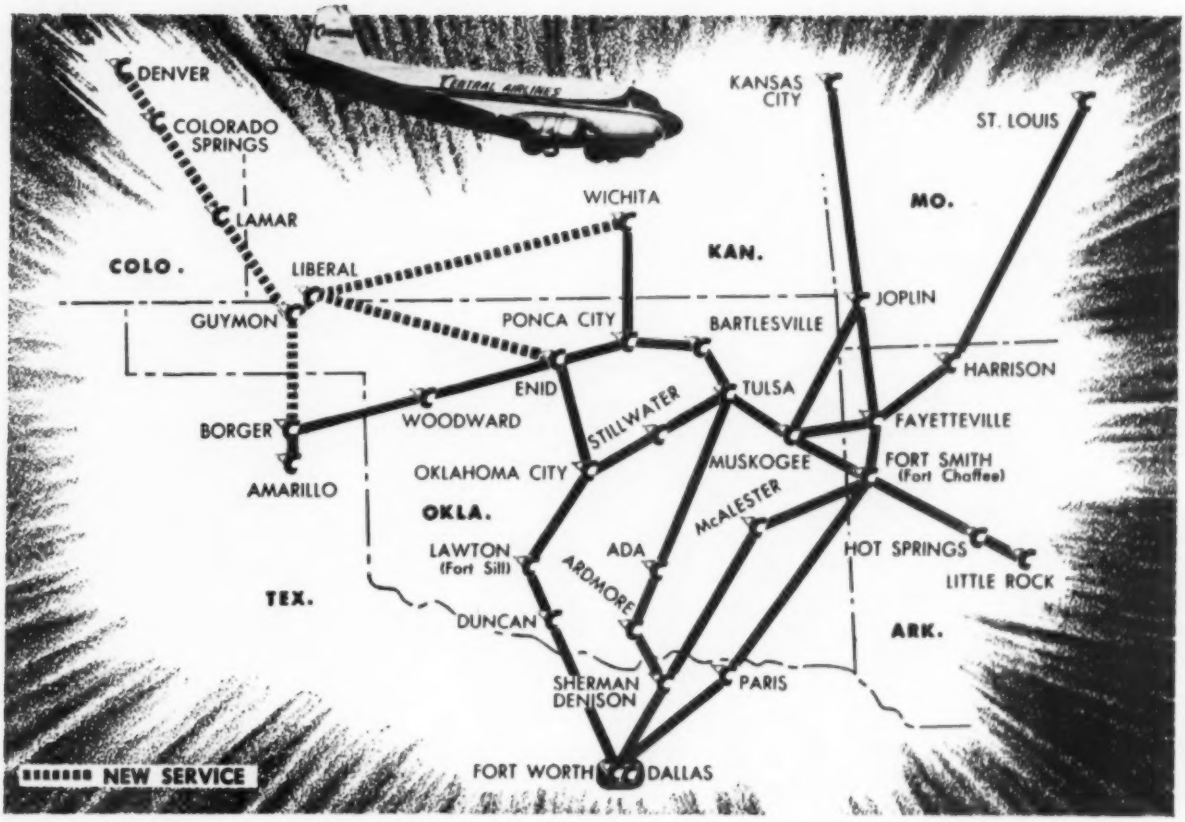
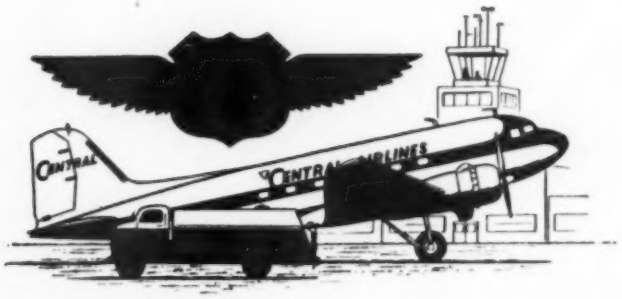
One in a series about users of Phillips 66 Aviation Products

Phillips 66 LOOKS AHEAD with CENTRAL

New service for Mid-America . . . Central Airlines recently added routes to Denver, Colorado Springs and other points in keeping with its policy of more and better service to the area. An important connecting line, Central serves 34 cities, 18 of them exclusively. Safety, speed, reliability and comfort are the watchwords that have made Central Airlines synonymous with improved commercial aviation in the Southwest and Great Plains.





● Today, Phillips 66 Aviation Gasoline gives dependable, efficient performance to Central and other leading air lines, as well as to the military air services.

In step with the future, Phillips is a leading producer of *super performance* Jet Fuels for the latest designs in turbo-props and jets. And Phillips research continues to lead the way for development of fuels for the aircraft of tomorrow.

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NEW

Trans-Sonics*

"TAPE-ON" SURFACE TEMPERATURE RESISTORS

for Temperature Telemetering

- NO THICKER THAN A PIECE OF TAPE
- OUTPUT UP TO 5 VOLTS WITHOUT AMPLIFICATION
- AVAILABLE IN VARIOUS RANGES FROM −300° to +400°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE
- NO HOLES TO DRILL — QUICK AND EASY "TAPE-ON" INSTALLATION

Trans-Sonics Type 1371 "Tape-on" Surface Temperature Resistors are precision resistance thermometers with a platinum resistance winding as the sensing element. These resistors which are no thicker than a piece of tape may be applied to *any surface* whose temperatures are to be measured. In a commutation circuit, they modulate standard telemetering transmitters without amplification. The new Type 1371 "Tape-on" Surface Temperature Resistors may be added to an installation using other Trans-Sonics temperature transducers without any further circuit modification. Each resistor is furnished with 6" long fibreglas-covered constantan leads. Write for Bulletin 1371 to Trans-Sonics, Inc., Dept. 7.

*Reg. Trademark

SPECIFICATIONS

SIZE: ¼" x 5/16"

Accuracy: ±2% of full scale range

Precision: ±0.5% of full scale range

Maximum Continuous Current: 20 ma rms (averaged over 1 second)

Environmental Operation Conditions
Vibration: 1" double amplitude, 0 to 22 cps ± 25g, 22 to 2000 cps

Shock: 100g in any direction, per paragraph 4.15.1 of MIL-E-5272A (10 milliseconds shock)

INSTANT INSTALLATION

As easy to apply as a thumb print.

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

P. O. BOX 328 LEXINGTON 73, MASSACHUSETTS

AVIATION CALENDAR

(*Continued from page 4*)

craft Engineering Display, sponsored by Society of Automotive Engineers, Hotel Commodore, New York.

Apr. 3-5—Spring Meeting, American Rocket Society, Sheraton Park Hotel, Washington, D. C.

Apr. 12—Latest Developments in Capsule Escape Systems, Douglas Aircraft Co. and Society of the Experimental Test Pilots, Lancaster, Calif.

Apr. 16-17—Aircraft Ball Bearing Conference, sponsored by New Departure Division, General Motors Corp., Statler Hotel, Hartford, Conn.

Apr. 22-24—Second Annual Jet Engine Hydraulics Symposium, Hotel Statler, Detroit, Mich.

Apr. 23-25—Annual Convention, International Airline Navigators Conficil, Piccadilly Hotel, N. Y.

Apr. 29—Third Flight Test Instrumentation Symposium, Statler Hotel, Los Angeles.

Apr. 29-May 2—16th Annual National Conference, Society of Aeronautical Weight Engineers, Broadview Hotel, Wichita, Kans.

Apr. 30—Atlantic Rate Commodity Rate Board Meeting, International Air Transport Assn., Torquay, Devonshire, England.

May 1-3—Spring Meeting and Exhibit Society for Experimental Stress Analysis, Hotel Statler, Boston, Mass.

May 5-8—30th Annual Convention, American Assn. of Airport Executives, Shamrock Hilton Hotel, Houston, Tex.

May 6-8—28th Annual Meeting, Aero Medical Assn., Shirley Savoy Hotel, Denver.

May 8-11—13th Annual National Forum, American Helicopter Society, Sheraton Park Hotel, Washington, D. C.

May 13-15—National Conference on Aeronautical Electronics, sponsored by Institute of Radio Engineers, Dayton, Ohio.

May 24-June 2—22nd Paris Air Show, Society of French Aircraft Constructors, Le Bourget Airport, Paris.

June 1-9—First Annual National Aviation Trade Show, Monmouth County (N. J.) Airport.

June 7-8—30th Annual Homecoming and Reunion, Parks College, East St. Louis, Ill.

June 23-25—29th Annual Meeting, Aviation Distributors & Manufacturers Assn. The Broadmoor, Colorado Springs, Colo.

July 2-11—24th National Soaring Contest, Elmira, N. Y.

July 12-13—British Lockheed International Aerobatic Competition, the National Air Races (third round) and the King's Cup Air Race, Coventry Civil Aerodrome, Bagington, England.

Aug. 20-23—Western Electronic Show & Convention Board of Directors, Cow Palace, San Francisco, Calif.

Sept. 1-6—Sixth International Aeronautical Conference Royal Aeronautical Society and Institute of the Aeronautical Sciences, Folkstone and London, England.

Sept. 2-8—1957 Flying Display, Society of British Aircraft Constructors, Farnborough, England.

Rendezvous at 15,000 (RPM)
Bearing: 600° (F)
Jet engine main shaft bearings face their most crucial test in the years just ahead. They must survive speeds and temperatures beyond any performance limits yet achieved.
At Rollway, new high-temperature steels are regularly examined in the unending search for greater precision and dimensional stability.
Starting with the engineers who adapt experimental goals and findings to the operating needs of customers, Rollway's service extends all the way from laboratory to delivery schedule.
Your delivery of Rollway precision bearings will be the end product of specialized aircraft experience, exhaustive analysis, and painstaking manufacture.
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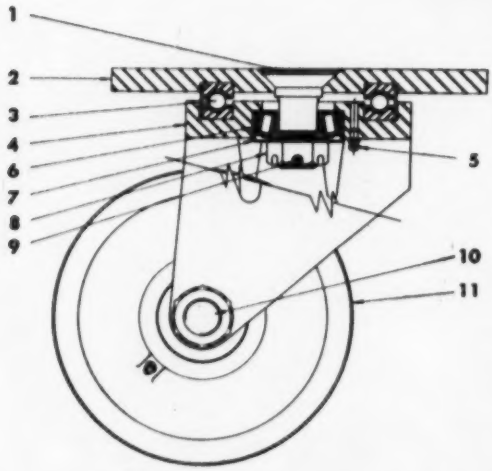
Faultless CASTERS

Move Maximum Loads with Minimum Manpower

Here is the super strong Caster you have wanted for handling those loads that broke down ordinary Casters. Faultless Engineers combined their finest materials and designs to provide a caster capable of easily rolling under 10,000 pounds without injury. Under heaviest rated load conditions the new HX300 Caster keeps production lines moving with minimum handling costs. This heavily proportioned Caster has extra strength features at vital points, combined with ideally-suited bearing style and construction at all moving points. Timken tapered roller bearings and self-contained ball bearings provide free swivel and rolling movement even under loads of 5 tons per caster.

For further information on the new HX300 Series Extra Heavy Duty Caster, write for Form No. 6256, no obligation.

SERIES HX300
EXTRA HEAVY DUTY SWIVEL PLATE CASTER
Rated Load: 5 Tons per Caster



1. HEAVY, 1" DIAMETER KINGBOLT . . . threaded and double cross-hole drilled for adjustment with each 30° turn of slotted nut.

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8. ADJUSTABLE, SLOTTED NUT.

9. HEAVY STEEL COTTER-PIN.

10. 1" DIAMETER AXLE BOLT . . . equipped with heavy nut and lock washer.

11. REINFORCED 8" OR 10" SEMI-STEEL WHEEL . . . Timken bearings protected with close fitting dust caps. V-Grooved wheels also available.

Where maximum IR sensitivity is desired—

New Perkin-Elmer Nitrogen Cryostats Cool IR Detectors to -196°C Conveniently and Safely

A new series of Nitrogen Cryostats for cooling infrared detectors to approximately −196° C has been developed by Perkin-Elmer. Rugged, reliable, and safe, these unique refrigerating units, available for both laboratory and military use, provide a new freedom in the design of infrared detecting equipment.

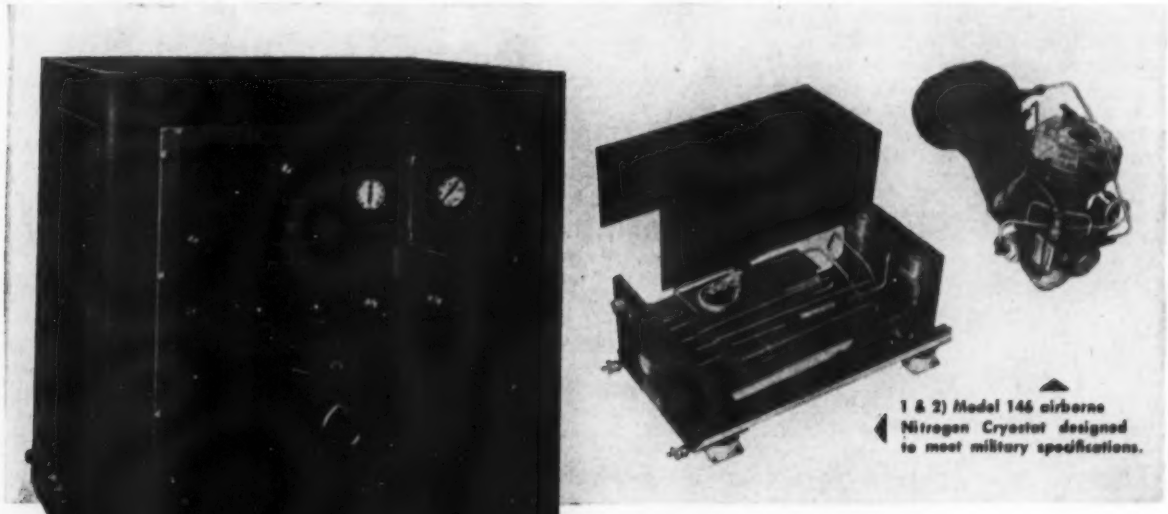
Unlike conventional open-flask coolers, the Perkin-Elmer Cryostats are completely closed recirculating systems. There is no danger of spilling, no loss by evaporation. The cooling heads, and thus the detectors, can be operated vertically, horizontally, or at any desired angle.

The Model 147 Cryostat, designed for laboratory use, consists of two basic components—a miniature cooling head and a compressor-regulator assembly. The cooling head utilizes the Joule-Thompson effect and the principle of regenerative cooling. Compressed nitrogen is passed through a highly efficient miniature heat exchanger where it is cooled by nitrogen returning from an expansion nozzle. The expanded gas is recovered and returned to the compressor for recirculation.

The Model 147 Cryostat System is designed to operate from a nominal 117 volt a-c power supply. Available with a variety of cooling heads, it is suitable for cooling infrared detectors, for cooling traps in vacuum systems and similar applications.

The Model 196 Cryostat System was engineered specifically for military applications. An extremely lightweight instrument, it is designed to meet JAN specifications, packaged for airborne installations, and operates from a 28 volt d-c power source. The 196 System consists of three parts—a pump assembly, regulator assembly, and cooling head.

Cooling heads with a heat pumping capacity of 1.5 to 5 watts are available to fit the wide range of sizes and shapes of re-entrant Dewar detector units.



1 & 2) Model 146 airborne Nitrogen Cryostat designed to meet military specifications.

3) Model 147 Nitrogen Cryostat for general laboratory applications.

ENGINEERING AND OPTICAL DIVISION

Perkin-Elmer *Corporation*

NORWALK, CONNECTICUT

FLUTTER DAMPERS

by HOUDAILLE

...performance proved for every control surface application

When flutter first became a problem on high-speed, high performance aircraft, Houdaille launched an intensive research program to develop high frequency flutter damping devices. Today Houdaille offers a wide range of designs in both rotary and linear types, to meet any control surface application . . . any envelope requirements.

Houdaille Flutter Dampers are completely self-contained, precision-built hydraulic mechanisms—specified by leading airfame manufacturers for their dependability and performance. Normally supplied with MIL-O-5606 fluid, available at all operational bases, they may be furnished with the new high-temperature fluids when specified. A thermostatic valve assures uniform damping characteristics over a temperature range of −65° to 300°F and above.

CONTINUOUS TESTING and rigid quality controls are standard procedure at Houdaille. Production dampers must undergo exhaustive tests for several days on equipment such as this, to make certain each unit meets all phases of the customer's specifications.

WRITE FOR TECHNICAL BULLETIN giving complete performance and operational data. For engineering assistance on flutter damping applications at the aircraft design stage, contact Buffalo Hydraulics Division, Dept. AW.

● Several individual engineering opportunities are available in complete product creation. Interviews are invited.

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BUFFALO HYDRAULICS DIVISION

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Pioneers in developing aircraft vibration-control devices

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INTERNAL ELECTRIC HOIST OPERATION

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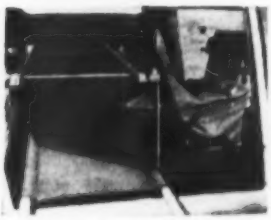

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Versatility Unlimited!

Newest of the famous Bell Model 47 family, the Ranger is truly an all-purpose helicopter with unlimited versatility.

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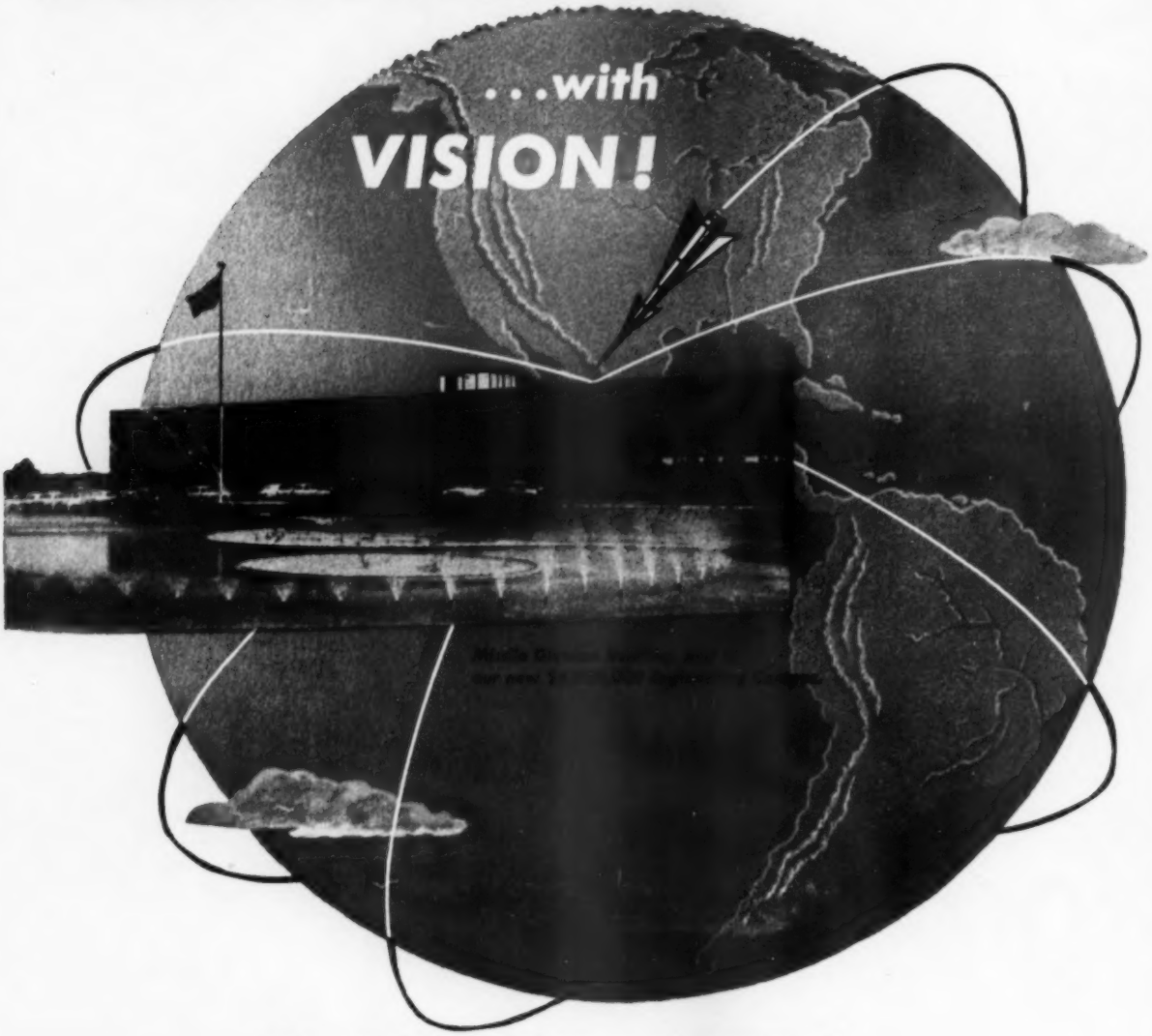
ENGINEERS



M.A.C. engineers must have the necessary vision to project their thinking into the future in a constant quest for more speed, versatility, greater range and dependability . . . hallmarks of McDonnell designed products! Some examples of this daring engineering spirit are the F-101 Voodoo—F3H-2 Demon jet fighters, the XV-1 Convertiplane, and the Talos guided missile.

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RAYMOND F. KALETTA
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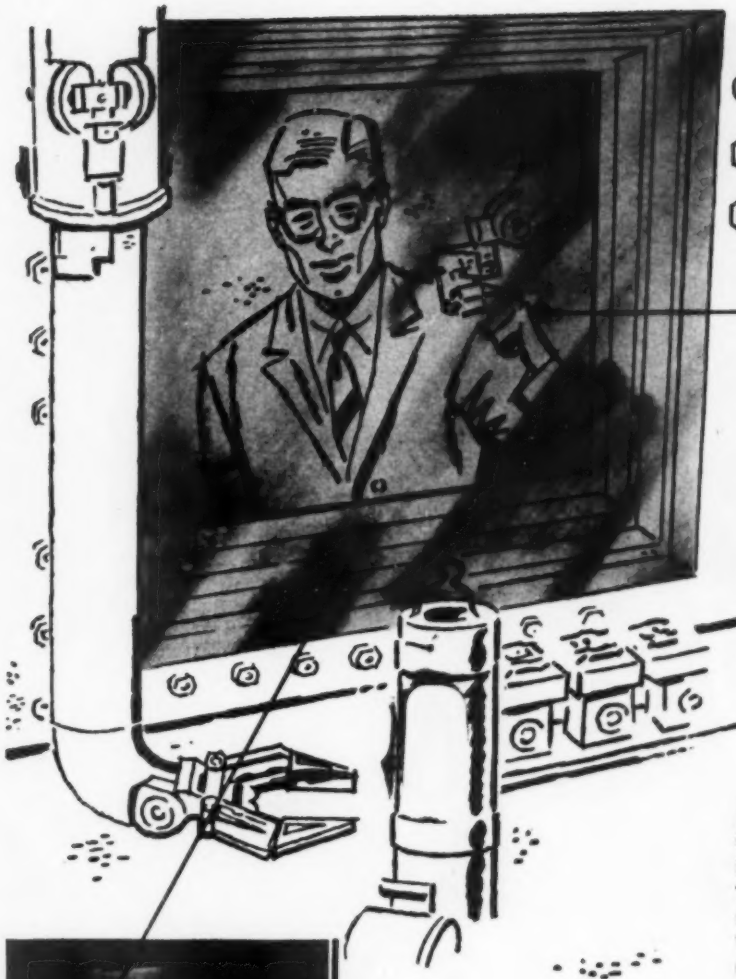
P. O. Box 516, St. Louis 3, Missouri

radiation shielding windows protected in transit by LORD shipping mountings

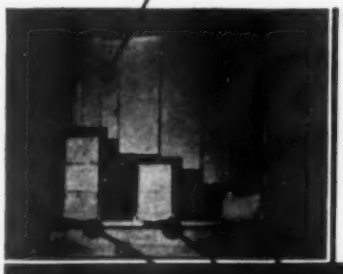


These 5000-pound glass castings used as shielding windows against nuclear radiation posed some unusual shipping problems.

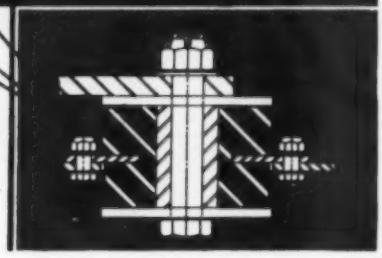
Transporting these observation windows from the Harrodsburg, Ky. plant of Corning Glass Works to the installation sites exposed them to costly and irreparable damage. The weight, and irregular shape of the windows complicated the problem.

Lord research and engineering produced an economical solution by flexibly supporting the windows on eight Lord bonded rubber mountings. The mountings isolate vibration and reduce shock which might damage the glass. This move has paid off for Corning—no windows shipped on Lord mountings have been damaged!

If damaged shipments are costing you time, money and poor customer relations, take advantage of Lord's experience and facilities. Contact the Lord field engineer nearest you or the Home Office, Erie, Pa.



Lord bonded rubber mountings provide a resilient but stable base for shipping massive glass casting.



Corning window is supported by eight Lord Heavy Duty Plate Form Mountings equipped with snubbing washers which limit and cushion excessive shock movement.

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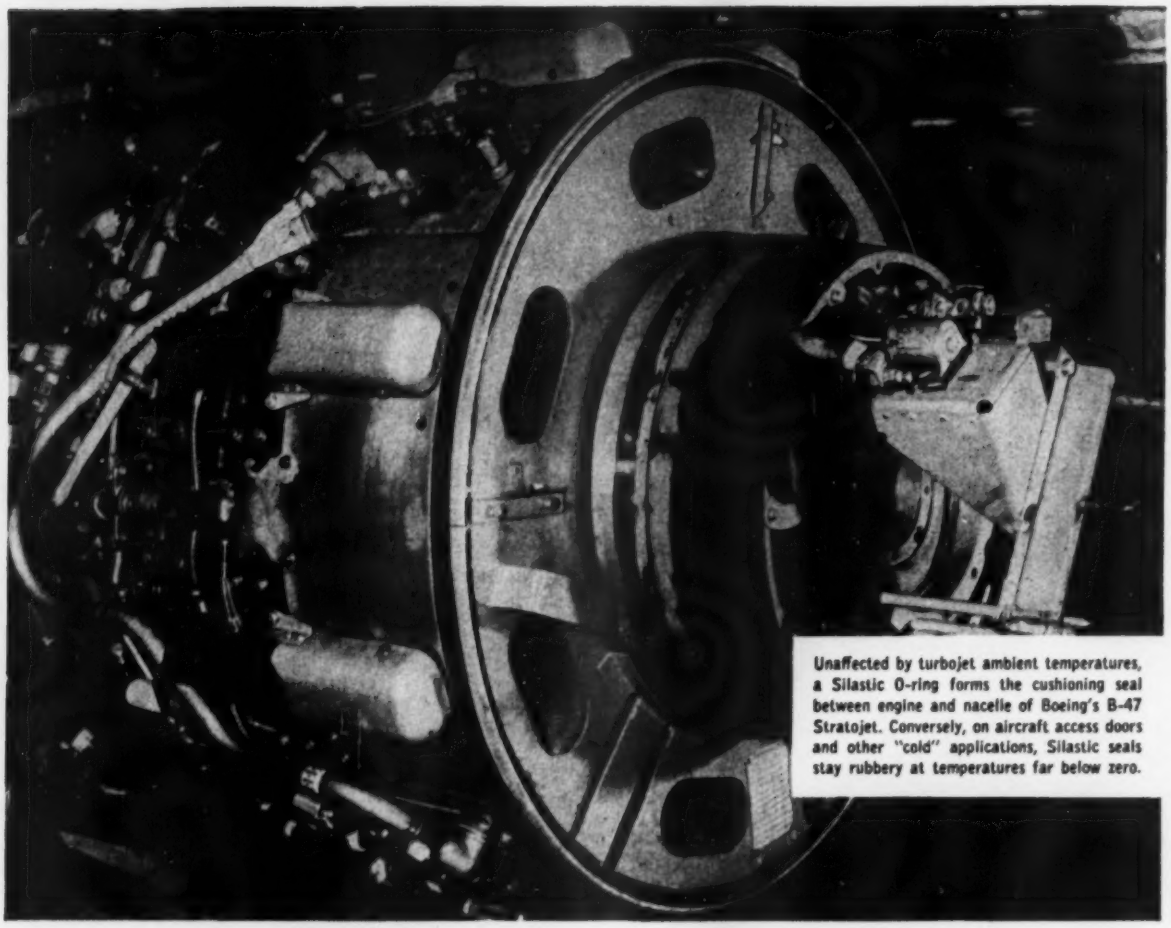
LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924



Unaffected by turbojet ambient temperatures, a Silastic O-ring forms the cushioning seal between engine and nacelle of Boeing's B-47 Stratojet. Conversely, on aircraft access doors and other "cold" applications, Silastic seals stay rubbery at temperatures far below zero.

SILASTIC O-rings seal effectively at 500 F

Ambient temperatures high enough to melt organic rubber, or low enough to make it brittle, never faze Silastic*, Dow Corning's silicone rubber. Flexible from −130 to 500 F, Silastic also has superior resistance to ozone, weathering, and chemical attack. Silastic O-rings of cross-section and circumference to meet your particular requirements are available through leading O-ring manufacturers.

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Typical Properties of Silastic for O-rings

• Temperature range, °F	−130 to 500
• Tensile strength, psi	600 to 900
• Elongation, %	100 to 300
• Tear strength, lb/in	40 to 75
• Compression set, %, @ 300 F	15 to 40
• Hardness range, durometer	20 to 80

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If you consider ALL the properties of a silicone rubber, you'll specify SILASTIC.

first in silicones — DOW CORNING SILICONES

DOW CORNING CORPORATION • MIDLAND, MICHIGAN

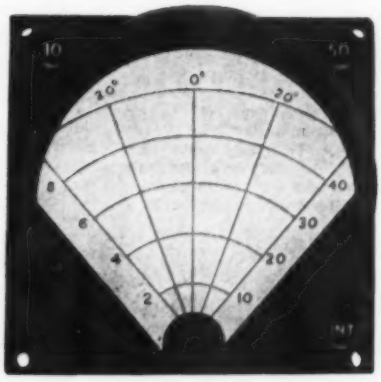
THE NOSE THAT KNOWS THE WEATHER

...and makes possible a faster, more comfortable trip!

That plastic "nose" you see encloses the business end of RCA's new weather avoidance radar (AVQ-50).

Specially developed for use in aircraft where weight, space and power are at a premium, the AVQ-50 is the latest addition to the RCA weather radar family.

It enables your pilot to pinpoint turbulent areas many miles ahead



and choose a smooth path around them. In the words of a pilot, it makes it possible to do broken field running instead of long, time-wasting end runs. It is also good for ground-mapping.

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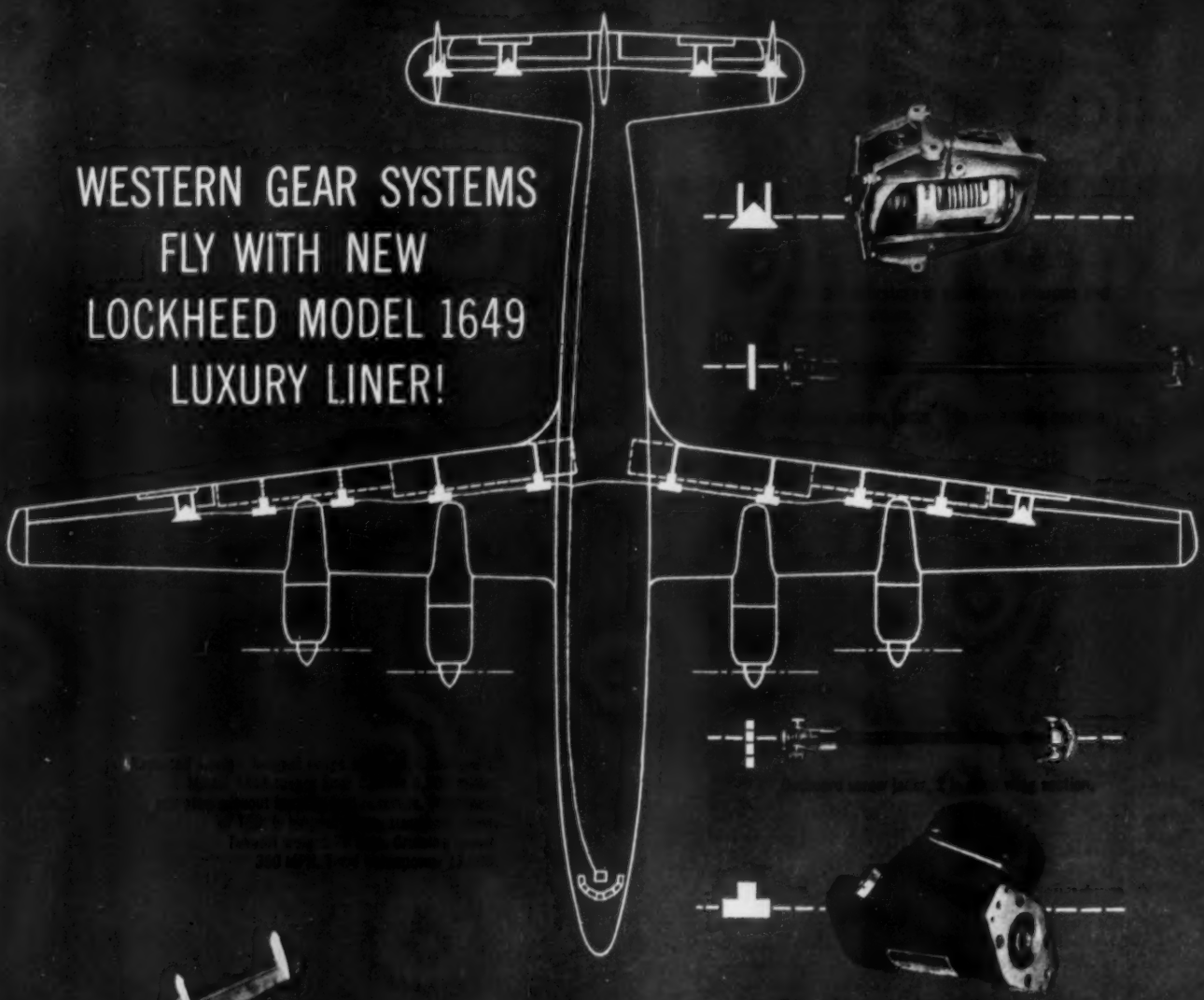

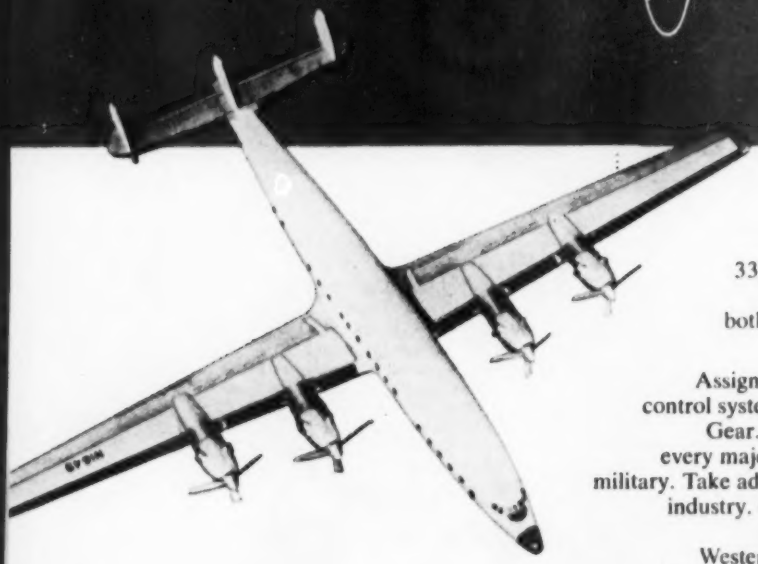

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MARCH 11, 1957

AVIATION WEEK

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COVER: Blunt 18-in. dia. nose cone of thin, highly-polished spun Inconel acts as a calorimeter for measuring heat transfer at Mach 5 in general study of blunt shapes at Wallops Island, Va. Wallops is site of Pilotless Aircraft Research Station of National Advisory Committee for Aeronautics' Langley Aeronautical Laboratories. Inconel is polished with diamond dust compound to a 2 microinch finish near tip, covered with special 1-in. thick padded bell cap to protect it from handling oxidation, etc., before firing. Thermocouples welded to underside of cone measure temperature rise. Pressure caps on surface detect pressure change. Boosters are Honest John, Nike. Note reflection of firing pads in mirror-like finish. For higher Mach numbers, smaller cones of about 5-in. dia. are mounted on four-stage rockets, some of which are fired over-the-top (AW Oct. 22, p. 52) to simulate missile re-entry speeds in dense atmosphere. For more on Wallops research, see page 51.

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69,476 copies of this issue printed

AVIATION WEEK • MARCH 11, 1957 • Vol. 66, No. 10
Member ABP and ABC

New fuel cell baffles 11,900 lb. surge pressure

When the spectacular Douglas F4D Skyray takes off from a Navy carrier, it blasts out and up at a record-setting pace.

Imagine the surge pressure set up in a longitudinal fuel cell by such a catapult take-off—or during an arrested carrier landing. It would be sudden and devastating—as much as 11,900 pounds of surge pressure that would burst a conventional fuel cell.

Obviously, this problem had to be solved before making test flights. Development engineers of the B. F. Goodrich Aviation Products division, called in by Douglas, worked out a solution.

They designed a cell containing a series of special baffles, dividing the interior into compartments. The baffles were reinforced with steel cables to soak up surge pressures and transmit them to the airframe. The resulting B. F. Goodrich fuel cell combined maximum strength with minimum weight. It is proving itself successful in every flight of a Skyray.

For the best solutions to your fuel cell problems, call upon experienced engineers of B. F. Goodrich Aviation Products.

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EDITORIAL

Salute to Polar Pioneers

Scandinavian Airlines System's opening of Copenhagen-Tokyo service last month blazed a new commercial trail between Europe and Asia and added another significant record of polar pioneering to this airline's already solid operational record. The post-war era has been full of commercial trail blazing by the airlines of the world with four engine, long range transports but none of these efforts have faced as tough a technical challenge as the SAS assault on the Arctic. How SAS developed the operational techniques and ground environment required for regular airline service over the Arctic wastes has been described in detail (AW Mar. 4, p. 37) by AVIATION WEEK's Richard Sweeney who was a passenger on the first regular SAS flight linking Asia and Europe. He has also flown over the SAS Arctic link between Europe and the Pacific Coast.

As in all successful pioneering efforts, the SAS polar achievements were based on a foundation of years of experimentation and preparation.

SAS also benefited from the Arctic work done by the U.S. Air Force and the Royal Canadian Air Force.

The first commercial airway across the Arctic linking Los Angeles with Copenhagen proved to be an economic success far beyond even the expectations of its sponsor. In two years of operation this SAS route flown by Douglas DC-6Bs has averaged a 73% passenger load factor plus an ever-growing volume of cargo.

Canadian Pacific Airlines has already followed in the SAS propwash across the Arctic, linking Vancouver with Amsterdam. Both TWA and Pan American World Airways have applied to the Civil Aeronautics Board for routes similar to the SAS pattern to link the Pacific Coast to Europe without funneling through the traffic bottleneck at New York.

The CAB examiner's report on the TWA and Pan American applications has been favorable and it shouldn't be too long before U.S. flag carriers will join the triumvirate emblem (Denmark, Norway, Sweden) of SAS on the Arctic airways.

Meanwhile a salute to the Arctic pioneering of SAS!

CAB's Jet Transport Salesmen

Members of the Civil Aeronautics Board have been engaged in a major effort to acquire the necessary technical background to prepare themselves for the advent of the jet age in commercial aviation. They have visited all of the major Pacific Coast transport manufacturers—Boeing, Douglas, Lockheed and Convair—flown in the Boeing 707 jet transport prototype, inspected DC-8 and Electra mockups and listened to sales and engineering pitches with patience and genuine interest.

They also made an effort to generate public assurance that the advent of the turboprop and turbojet in commercial airline service would offer the traveling public better service and the investing public profitable airline operations. This was done at a press conference in which verbal praise for jet transports in general was liberal but no specific endorsements of any specific aircraft were issued by the Board in writing.

No doubt stimulated by the success of its West Coast excursion the Board continued its educational efforts by journeying to the pleasant Maryland pastures of Hagerstown to inspect the burgeoning gas turbine transport development program of the Fairchild Engine and Airplane Corp.

Perhaps because they could find no assembly of working press in Hagerstown or perhaps because of an underdeveloped sense of the ethics and propriety required by their position as CAB members, they did a strange and totally improper thing. They issued a press release under the official CAB blue letterhead imprint giving fulsome endorsements by CAB members of specific Fairchild transports—the Fokker-designed F-27 turboprop Friendship and the M-185 turbojet powered executive aircraft. After 400 words of this praise including a general statement on behalf of the Board and specific endorsements from CAB Chairman James R. Durfee and members Harmar Denny and Chan Gurney, the statement contained a footnote as follows:

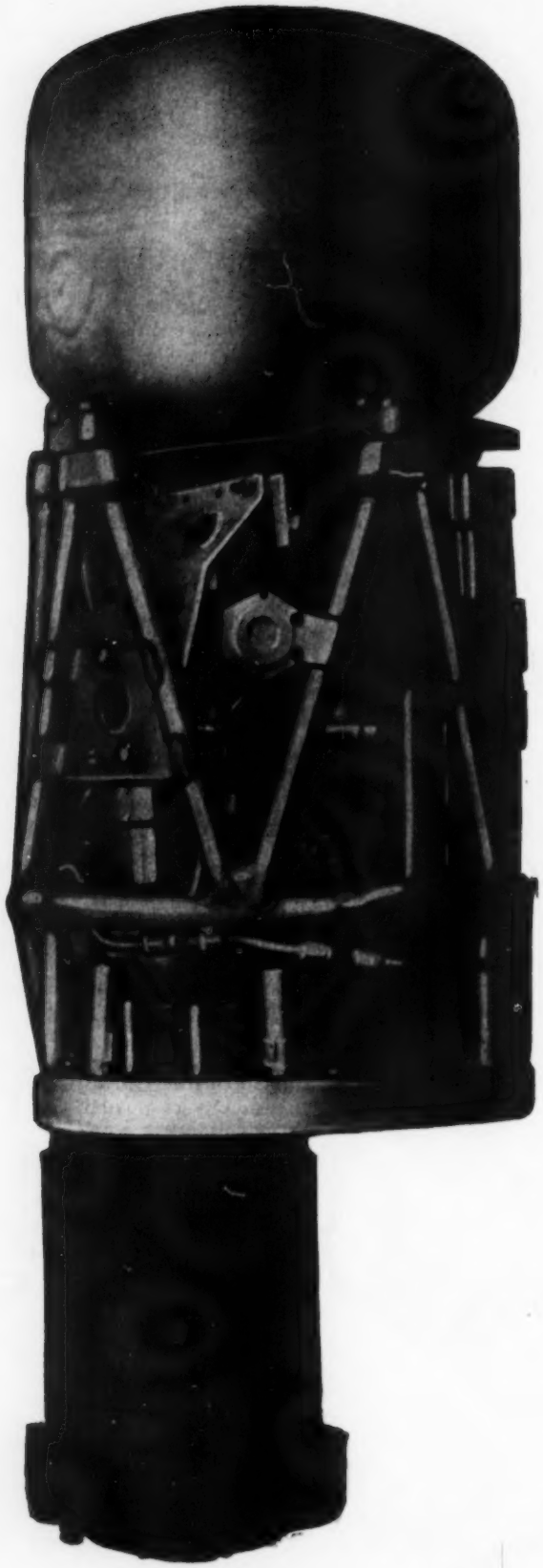
"The Board emphasized that selection of equipment by air carriers is a matter of managerial discretion and that its statements concerning its jet orientation tour do not constitute prior approval of airline purchases."

Perhaps too, Fairchild's enthusiasm and the protests of the other manufacturers who have been grossly discriminated against in this CAB press release have been tempered by the fact that since the departure from the Board of Joseph Adams, there is not a single member whose technical aeronautical qualifications enable him to distinguish between his elbow and an aileron.

The Board deserves commendation for its efforts to get out and around the airlines and transport manufacturing industry in order to acquire a better understanding of the industry it regulates.

But the Board does nothing to enhance its position as a quasi-judicial, impartial federal agency by its excursions into cigarette ad type testimonials for equipment manufacturers or its ill-advised attempt to secure free airline rides of a year ago.

—Robert Hotz



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As a part of its power system development program, Kidde has gained wide experience with many monopropellants. These include ethylene oxide, hydrazine, hydrogen peroxide and propyl nitrate.

Whatever your present or future auxiliary power requirements, Kidde is ready to develop, test and manufacture equipment which will meet your exact specifications. For full information, write Kidde today.

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WHO'S WHERE

In the Front Office

Clinton Davidson, Sr., board chairman and chief executive officer, Resort Airlines, Inc.

E. K. Meredith, board chairman, and **Karl Weber,** president, Weber Aircraft Corp., Burbank, Calif. Also: **Arnold Johnson,** vice president and general manager.

William A. Barr, board chairman, and **James R. Fagan,** president and treasurer, Foote Bros. Gear & Machine Corp., Chicago, Ill.

Dr. Marshall G. Holloway, president, Nuclear Energy Productions Division, ACF Industries Inc., Washington, D. C.

Harry A. Donahue, Jr., vice president, Aviation Division, Marion Electrical Instrument Co., Manchester, N. H.

Frank M. Viles, Jr., vice president-manufacturing (semi-conductors), Federal Telephone and Radio Co., Clifton, N. J.

Louis Achitoff, vice president-operations, Flight Safety, Inc., New York, N. Y.

Earle W. Barry, vice president, Trecker Aircraft Corp., Milwaukee, Wis. Mr. Barry will be in charge of sales of Royal Gull amphibians in Latin America.

M. Anthony Sonnino, vice president and treasurer, Southwest Airways Co.

Dudley Saward, managing director, Texas Instruments Limited, Bedford, England. Texas Instruments Limited is newly established English subsidiary of Texas Instruments, Inc., Dallas, Tex.

Honors and Elections

Gen. Edwin W. Rawlings, commander, Air Materiel Command, has been selected to receive the Gen. William E. Mitchell award as the American who has done the most for aviation in the past year. Gen. Nathan F. Twining, Chief of Staff, USAF, will present the award at the annual dinner on April 10.

Walter Binaghi of Argentina has been elected president of the Council of the International Civil Aviation Organization, Montreal, Canada. Mr. Binaghi succeeds **Dr. Edward Warner** of the United States, retiring after having served as president since the council was formed 12 years ago.

John Jay Hopkins, chairman and president of General Dynamics Corp. has been named a chevalier of the Legion of Honor by the government of France in recognition of his role in international aviation and for his efforts "to bring the blessings of nuclear energy to the underprivileged peoples of the world."

Changes

T. I. Paganelli, manager-special radar projects section, Heavy Military Electronic Equipment Dept., General Electric Co., Syracuse, N. Y.

George H. McKaig, manager-production planning, and **James T. Jones,** manager-production engineering, Hughes Aircraft Co., Culver City, Calif.

William E. Crowell, head-Weapon Systems Design Dept., Cornell Aeronautical Laboratory, Buffalo, N. Y.

INDUSTRY OBSERVER

► Leading contenders in USAF competition for a helicopter to be used for local crash rescue missions are the Sikorsky S-55 and Vertol H-21. USAF, whose final decision is imminent, wants an off-the-shelf item and may order as many as 200 helicopters. Later models of either the S-55 or H-21 probably will be turbine powered.

► **Alaskan Air Command will bolster its atomic striking force within the near future with a guided missile group armed with the latest version of the Martin TM-61 Matador. This version of the Matador will have an atomic warhead and an improved guidance system to extend the missile's effective range.**

► General Electric has begun studies aimed at producing higher power versions of its T58 axial-centrifugal shaft turbine engine and its small J85 turbojet. Present T58 rating is 1,024 eshp. J85's thrust is in the area of 2,500 lb. Aim for the J85 is to obtain a thrust-to-weight ratio of 10 to 1.

► **Air Force version of Bell Aircraft Corp.'s automatic all-weather landing system (AW March 4, p. 32) will fit into two standard two-wheel trailers that can be airborne in Fairchild C-119 Packets.**

► Winner of Army-Navy competition for a higher performance aircraft is expected soon. March 1 target date already has passed. Prototype and engineering evaluation will be carried out by the Navy. Army later will acquire five of the aircraft for its own evaluation. Requirements call for an aircraft capable of carrying electronic gear over a battlefield, have a speed of 275 to 300 kt. and be able to land and takeoff over a 50-ft. obstacle within 600 ft.

► **Moscow sources say the new Ilyushin turboprop transport (AW July 2, p. 27) is now flying and will go into Aeroflot service within "the near future." Russians claim the four 4,000 eshp. turboprops powering the new airliner have a lower fuel consumption than the Rolls-Royce Dart. The new transport has been named the "Ukrania" and carries up to 70 passengers in a pressurized cabin.**

► Armed version of the Sikorsky S-55 for ground support missions is being developed by French authorities in Algeria. Test version is equipped with three machine guns and one 57 mm. recoilless cannon which is fired from the loading door. Cannon can be replaced by a rocket launcher. The armed S-55 carries two pilots and a three man crew to handle the armament.

► **French air force has formed its first unit in Algeria to be composed entirely of French-built helicopters. Six Sud Aviation Alouette IIs recently were sent to the French helicopter base at Boufarik to join two Alouettes that had completed a test program there. The unit is scheduled to reach its full strength of 12 helicopters sometime this week.**

► Six rocket projects now being carried out by the Naval Ordnance Test Station, China Lake, Calif., represent 17% of the station's total effort. Two years ago the figure was 40%. Decline is due primarily to an increasing shift to guided missile work. An important phase of the station's research program is determination of the differences between detonation and burning in missile and rocket propellants.

► **Boeing Airplane Co. has become the first airframe manufacturer to purchase GCA quadradar. Unit is used to guide aircraft to Boeing Field from altitudes as high as 50,000 ft. and as far out as 40 miles. It also allows straight-in jet penetrations to save time and fuel and permits the monitoring of test flights in the Seattle area.**

► Chance Vought's F8U-1 Crusader has completed its fleet indoctrination program, and aircraft are being delivered to Cecil Field, Fla., where VF-32, Navy's first Crusader squadron, will train. A composite squadron, VF/AW-3, will be organized on the West Coast next month to form a personnel nucleus for other F8U squadrons.

Frozen on the outside, warm and ready to go on the inside!

The "Mars" makes the difference*

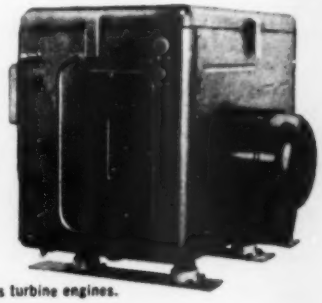
EXTREME COLD in Arctic operations has little effect on the compact, reliable Mars auxiliary power unit used on the Boeing KC-97 tanker. Often running continuously day in and day out, the dependable Mars-powered generator set keeps the cabin comfortable at below-zero temperatures. It supplies electric power also for engine preheating and starting systems as well as for other auxiliary equipment.

Solar's 50 hp Mars gas turbine is the heart of the airborne power unit. The Mars engine weighs less than 100 pounds, is smaller than a two-foot cube. It starts easily from 130F to −65F ambient temperatures, operates on a variety of fuels, is simple to maintain, and requires infrequent overhauls. In addition to the KC-97, Mars auxiliary power units are employed on the Douglas C-124C, the Lockheed C-121C and Convair C-131B.

Perhaps the Mars gas turbine can help solve your need for a light, compact, powerful engine. Write to Dept. C-142, Solar Aircraft Company, San Diego 12, California, for more data on the Mars gas turbine.

WRITE FOR BOOKLET

New brochure describes Solar gas turbines—how they work, advantages they offer. Ask for a copy.



SOLAR
AIRCRAFT COMPANY
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DES MOINES

*Mars is the registered trade mark for Solar's line of 50 hp gas turbine engines.

Washington Roundup

Wall Street Reaction

Pentagon news releases on the aircraft procurement program are having their effect on Wall Street this month.

Fast on the heels of the Boeing-Convair flurry set off by Defense Secretary Charles E. Wilson's comments on the relative merits of the B-52 and B-58 (AW March 4, p. 25) came a similar wave of activity in Republic and North American stocks. This time it can be traced to a USAF announcement which was released at the improbable hour of 10:30 p. m., that Republic's F-105 fighter-bomber had been chosen for production over North American's competitive F-107. Because of the hour it was released, the news failed to receive wide circulation in morning newspapers. It did appear, however, on page one of the Wall Street Journal.

Soon after the market opened, a block of 16,500 shares of Republic stock moved at 29¼, up four points over the day before. Two days earlier, Republic had been down to less than $25, following a company announcement that it was discharging 4,000 production workers.

News of the decision caught many people by surprise, particularly North American. USAF evaluation of the two aircraft showed the F-105 and F-107 to be similar in performance. The F-105 holds a slight speed advantage, the F-107 a favorable margin on range and payload.

Wilson's earlier comments on the possibility of the B-58 as a successor to the B-52 caused a sharp decline in Boeing stock until the Air Force issued a statement assuring brokers and stockholders that production orders for the B-52 would not be cut.

Jupiter Abort?

Army's Jupiter intermediate range ballistic missile apparently aborted on the pad recently during a scheduled test firing from USAF's Missile Test Center at Patrick AFB, Fla. In answer to queries, the Defense Department would admit only to the fact that "a" guided missile had aborted.

Thomas Leads Way

Navy Secretary Charles S. Thomas' scheduled departure from the Pentagon is the first of an expected series of changes in top secretarial posts, including those of Defense Secretary Charles E. Wilson and his deputy, Reuben B. Robertson, Jr.

Thomas, whose resignation is effective April 1, will be succeeded by Thomas S. Gates, Jr., Navy Undersecretary since 1953. Gates, a retired captain in the Naval Reserve, served as an intelligence officer in Europe and the Pacific during World War II.

Pentagon reports say Wilson and Robertson probably will resign at least by the time Congress adjourns.

Proximity Indicator Plea

Air Transport Assn. is renewing efforts to encourage the development of acceptable airborne proximity warning indicators and automatic collision avoidance systems. ATA has compiled, and is sending to U. S. electronic equipment manufacturers, a new "statement of System Specifications for Proximity Warning Indicator and a Collision Avoidance System."

Earlier this year, Collins Radio Co. voluntarily canceled almost $10 million in airline and executive aircraft orders for proximity warning and collision avoidance equipment (AW Jan. 14, p. 26). At the time, Collins said its studies had raised "grave doubts whether collision detection and avoidance equipment can be developed with presently available techniques in a practical form to meet airline equipment requirements." ATA will consider any new proposals at a meeting scheduled for the second week in April.

Ceiling Unlimited

Protest by the House Government Information Subcommittee over the "verbal classification" of a recorded telephone flying-weather forecast (AW Mar. 4, p. 25) brought prompt Defense Department action.

Rep. John Moss (D.-Calif.), subcommittee chairman, pointed out in a letter to Defense Secretary Charles E. Wilson that, although the forecast could be obtained by calling an extension listed on the front of the Pentagon telephone book, it ended this way: "This information is for military use only and dissemination to the public is not authorized."

As a result of the complaint, the forecast now ends this way:

"This forecast has been prepared for use by military personnel in the Washington area."

Civil Air Hearings

Sen. Mike Monroney (D.-Okla.), chairman of the Senate Commerce Aviation Subcommittee, hopes to start hearings by the end of the month on these four proposals affecting the airline industry:

- **Legislation introduced** by Sen. Warren Magnuson (D.-Wash.), chairman of the full Commerce Committee, that would establish an Office of Civil Aviation Medicine within the Civil Aeronautics Administration to keep a closer check on pilot physical requirements.
- **Proposal by** Sen. George Smathers (D.-Fla.) that airlines be given flexible certificates to permit shifts of operations to meet seasonal requirements such as the heavy winter traffic demand for service into Florida.
- **Legislation introduced** by Monroney directing the Civil Aeronautics Board to grant permanent certificates to scheduled all-cargo carriers.
- **A proposed banning** of alcoholic beverages on all airliners.

Increased Activity

Watch for increased activity by the Strategic Industries Assn., a West Coast based organization which describes itself as a group of "defense specialty manufacturers, designers, processors, makers of sub-systems and components."

Representing, for the most part, a group of small business firms, the organization last week held its first Washington meeting. The main speaker was Dudley C. Sharp, USAF Assistant Secretary for Materiel.

SIA will oppose government-built facilities, delays in contract settlements; favor faster contract payments to lower-tier suppliers and the plundering of proprietory rights. The group now has 110 active members, half of which are subcontractors in the field of aircraft and missiles.

—Washington staff

Navy Shows Sidewinder's Lethal Power

Missile kills F6F drone in China Lake demonstration; other rockets, bombing techniques are seen.

By Irving Stone

China Lake, Calif.—Lethal punch of the Navy's new XAM-N-7 Sidewinder air-to-air guided missile was demonstrated publicly for the first time at the Naval Ordnance Test Station when its infrared (heat-seeker) guidance took the streaking missile into an F6F target drone, knocking it out of the sky.

While the relatively slow piston-powered target was a "sitting duck" for the fast F3H-2N Demon firing plane and its Sidewinder missile, it was purposely used so that Sidewinder effectiveness could be demonstrated at close viewing.

The clouded sky would have obscured any normal operation of high altitude attack on a jet drone.

Sidewinder Operational

The ground-controlled F6F, fitted with flares to accent the simulation of a jet engine for targeting the missile's heat-homing guidance (AW Mar. 4, p. 50) came over at about 200 kt. and 2,000 ft. altitude. Swooping in at about 500 kt., the firing plane unleashed one of its Sidewinders when it was about a mile away. In what seemed about an instant after the flash of the rocket exhaust motor, the Mach 2.5 missile exploded at the drone, blowing off the tail.

Created at NOTS, the Sidewinder is the first guided missile conceived, developed and initially produced by a government laboratory. Its performance extends the range at which a fighter pilot can kill an attacking aircraft, boosts kill probability substantially.

Simplicity and reliability of the missile are unusual. Reports are that a kill probability proportion of 9 out of 10 ultimately will be attained. Figure now is said to be 7 out of 10.

Now in Production

Now in production by Philco Corp. and General Electric, Sidewinder is operational with Atlantic and Pacific fleet units (AW Oct. 26, 1956, p. 33). Aircraft which now or will mount it include F9F-8, FJ-3, FJ-4, F8U (which will carry the missile on fuselage side just ahead of wing root), F4D, F3H, and the Air Force's F-104, F-100 and F-89.

In its continuing development, it has been fired at F-80 drones and Regulus drone missiles.

Impact is generally right up the jet tailpipe.

The missile, about 9 ft. long and 4½ in. in diameter, is supported on a pylon-type rail launcher by three sliding-type lugs attached to the fuselage body.

Four canard triangular control fins are pivoted at about one-third from the fin forward point. Control fin leading edge measures approximately 11½ in., trailing edge length is about 5 in.

Four stabilizing fins on the end of the missile each have a slant forward section about 10 in. long, followed by a straight portion about 14 in. long. Trailing edge portion is approximately 7¾ in.

Other demonstrations at NOTS included rocket firings, bombing techniques, rocket sled run, tow target maneuvers and Terrier firing.

Impact power of the air-to-ground Zuni, 5-in. dia. experimental Mach 3 rocket expected to replace HVAR, was highlighted with eight of the units fired in pairs at one-second intervals, giving off loud sonic booms and ploughing into the ground to straddle the target. Delivery was from an F9F-8 Cougar traveling at 400 kt. and diving at 30-deg. along a 2,500-yd. slant range.

Zuni is 110 in. long, weighs 107 lb., has jet-operated folding fins. It will take a variety of warheads to accommodate a number of tactical missions. Fusings also are interchangeable and include influence, contact and time-delay types.

New Record

A new record was established when 194 Mighty Mouse 2.75-in. folding fin aircraft rockets were fired in a single pass by an AD-5 Skyraider which came in high, dove on the target as it released its charge.

Previous record had been established about a year and a half ago, when 154 of the 2.75-in. FFARs were fired in a single pass.

First of a series of bombing techniques was demonstrated by an F9F-8 Cougar, which came in at about 15,000 ft., dove, released its bomb to hit the target area while the plane made its getaway with a sharp turning climb to the left.

Over-the-shoulder delivery was demonstrated with an A4D Skyhawk, which first streaked in at the deck at 520 kt., approached the target area, pulled up into a high inverted loop, with the bomb being released as the plane climbed into the turn. As the bomb continued upward and described a large arc in its downward path to the target area, the A4D was well on its way in the opposite direction, far from where the bomb's blast perimeter normally would extend.

In a second pass, a medium-angle loft bombing was performed with an A4D.

This was followed by another run with a third Skyhawk demonstrating

Sidewinder Described in Detail

Navy's infrared seeking Sidewinder, characterized by simplicity and logic of design, has the seeker occupying approximately the first 4 in. of the nose. This is followed by guidance section, servo system between control fins, warhead, influence fuse, and rocket motor.

The rocket motor is 75 in. long, has 7-in.-long nozzle with 3-in. inside diameter. Burning time is approximately 2 sec.

Propellant grains are processed into sheets which are rolled into cylinder. This is put through extrusion press for compacting and homogenous effect. Grains burn from the inside out, affording insulating effect for the missile shell.

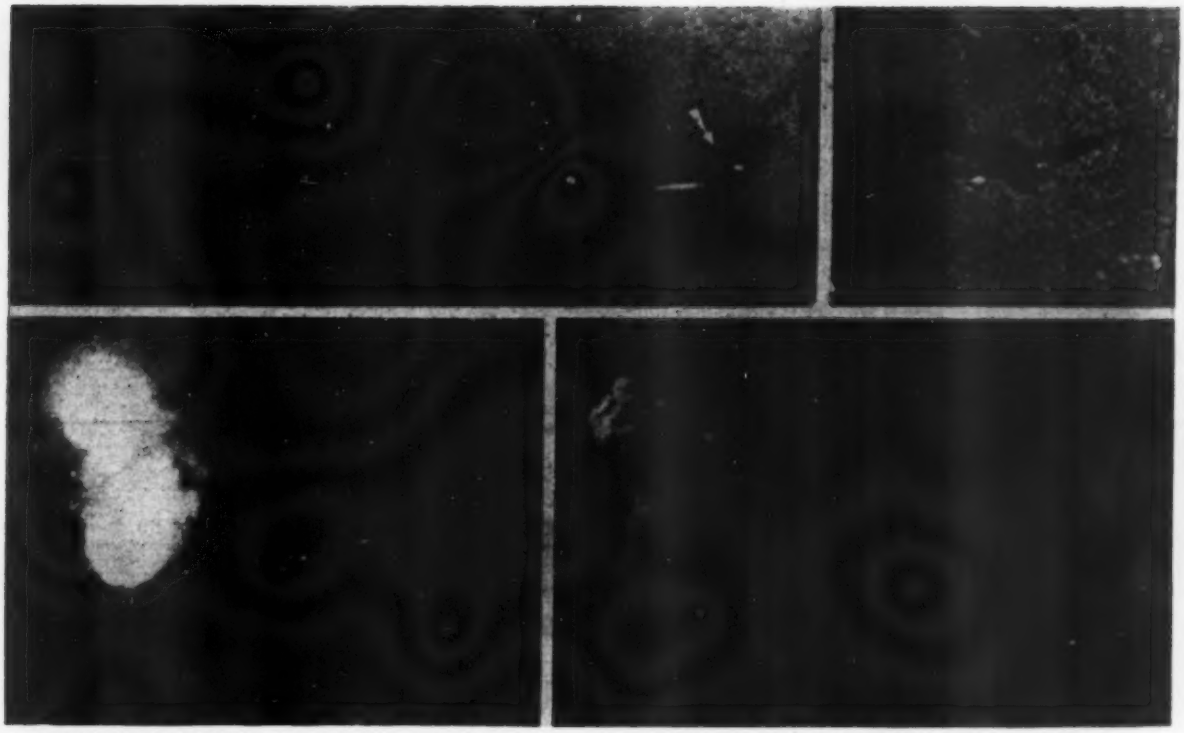
Under study is another version of the rocket motor which includes booster and sustainer.

The seeker is operative from moment of plane takeoff. Electric power to missile is through plane-missile umbilical connection located on missile top between control fins (for further infrared details, see Part II of Aviation Week's series on page 78).

When pilot hears signal from seeker through earphones, he triggers switch sending impulse through umbilical. This brings into play small solid-propellant gas generator which operates turbo-generator. This arrangement makes available power for the guidance and control actuating servo. Generator also provides current for igniting squib which fires rocket motor. As missile moves off pylon, umbilical connection is sheared.

At high altitude, missile range approaches 30 mi.

With hit, contact fuse sets off warhead. With miss, influence fuse activates warhead for target kill by blast and fragmentation within limited distance.



SIDEWINDER fired by F3H Demon (top) blows tail off F6F drone. Flares on drone simulate turbojet radiation characteristics.

a low-angle bomb pitchoff, with trajectory considerably flatter than before, for an air burst at about 1,500-ft. over the target.

Tow target maneuverability was demonstrated with the NOTS-developed Dart, a simple inexpensive triangular plywood configuration 12 ft. long and having a 4-ft. wing span, capable of being pulled at the jet tow plane's speed capability without restricting the plane's maneuverability.

Dart was towed at the end of a 2,000-ft. 7/64-in. nylon line by an F2H-2 Banshee. The line's elasticity stretched the length to approximately 2,500 ft. as the Dart trailed about 200 ft. below the Banshee, which streaked along at 250 kt. in level flight.

The Banshee pulled up sharply, went into an Immelman turn, the Dart following smoothly to the point where the maneuver began, continuing smoothly through the maneuver after the tow plane.

On-the-Shelf Item

In a second run, the Banshee went through a few rolls, then climbed steeply, with the Dart, following the maneuver.

At about 5,000 ft., the Dart was released, its chute popped, lowering it to the ground for intact recovery.

The tow target has been pulled with lines as long as 10,000 ft. with excellent results.

It has been developed to the point where it is an on-the-shelf item for both Air Force and Navy.

Followup of a Terrier launching was obscured by a heavy cloud bank. Target was an F6F drone flying at an altitude between 8,000 and 10,000 ft. and trailing smoke to assist the Askania-equipped tracking stations.

Intercept, which took place behind the clouds, was with the use of a proximity fuse which fired a spotting charge (smoke puff), instead of having the Terrier hit the target.

300 Terriers Fired

More than 300 Terriers have been fired at NOTS since the Navy's evaluation was begun in 1954. Report is that the missile has chalked up an impressive effectiveness of about 80% with the fleet.

Terrier now is carried by the guided missile ships Boston and Canberra and also by a destroyer.

High speed rocket sled run was demonstrated on SNORT (Supersonic Naval Ordnance Research Track.)

Projected to serve as a gap between wind tunnel and free-flight testing, this facility was built in 1953. It is adaptable for testing rockets, guided missiles, aircraft components under conditions approximating supersonic flight, launching rockets or missiles from the speeding sled (Sidewinder has been launched on this track), and checking on aircraft ejection seat characteristics.

Largest unit to be tested on SNORT is the forward portion of the B-58 hustler fuselage with its three personnel compartments.

In ejection tests, the three seats eject in sequence. Forward wall of each compartment is studded with floodlights to aid camera recording. The B-58 unit is propelled by three large Aerojet Jatos.

Falcon guided missile also was studied on SNORT to investigate characteristics of missile separation from the plane at flight velocities.

SNORT is now being used for sonic boom studies. Shock patterns are being checked to determine feasible limits for supersonic planes flying over inhabited areas.

Scheduled soon are tests of inertial guidance components for missiles.

Demonstration Run

In the demonstration run on SNORT a missile nose section was used on the main sled, powered by four Tiny Tim aircraft rockets, each burning for one second and packing 32,000 lb. thrust. Booster sled also was powered by Tiny Tims. Booster was ignited first, burned out and dropped behind at about 475 ft. down track because of its higher drag.

Main sled, which had its rockets ignited when it had been pushed to about 400 fps., accelerated to 1,500 fps. as it sped down the track, finally to be stopped by water braking. Highest speed attained during test runs on SNORT is 2,200 fps.

FIRST flight photo of Chance Vought Regulus II emphasizes high fineness ratio of 57-ft. vehicle. Powerplant is General Electric J79.

Regulus II Unveiled, Navy Gives Details

Washington—Production models of the Navy's Chance Vought Regulus II ship-borne guided missile will be powered by the General Electric J79 turbojet engine and operate at altitudes of over 50,000 ft. Speed will be more than Mach 1.5—probably close to Mach 2—and range is estimated at 800 to 1,000 miles.

Tests Almost Complete

In a series of disclosures at a Navy League luncheon here, Rear Adm. John E. Clark, director of the Guided Missiles Division for naval operations, said land-based tests are almost complete and that Regulus II will soon be operating from ships and submarines.

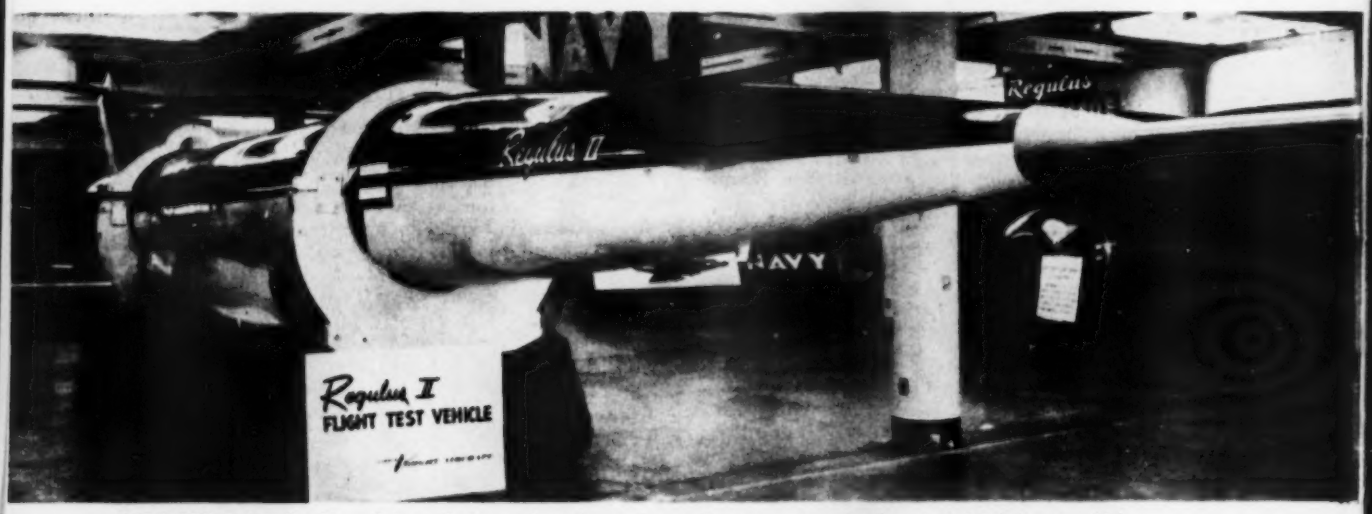
The previously top-secret missile, Admiral Clark said, will eventually carry a nuclear warhead like all other Navy missiles. The Regulus II is considerably larger than the Regulus I, resembling a conventional fighter plane. It is 57 ft. long, has a wing span of 20 ft.

An AVIATION WEEK drawing of the Regulus II appeared in the Dec. 10 issue (p. 29).

The Regulus II has a canard configuration with small stabilizers well forward of the wings and near the missile's needle nose. The J79 engine is equipped with an afterburner. Immediately above the belly air intake for the engine there is a scoop which bleeds off low energy boundary layer and dumps it out of vent on fuselage beneath the wing.

'Test Vehicle'

A model, placed on exhibit for the first time for Washington Navy League members, was labeled a "test vehicle," and Navy officers said it was not a



SUPERSONIC Regulus II model on display carries telemetering equipment, not warhead, so it is labeled test vehicle.

model of the operational weapon. Adm. Clark, however, made it clear that the only difference between the model and an operational missile is that test instrumentation will be replaced by a warhead.

He said the Regulus I and II use the same Sperry-developed autopilot, beacons and recovery system, making them identical except for size and performance.

Polaris Progress

Designed for use against heavily defended shore targets, the Regulus II, Adm. Clark said, has performed "beyond expectations" in tests at Edwards AFB.

The missile can be landed, and the Navy has been averaging nearly four flights for each missile.

Adm. Clark also revealed that Polaris, Navy's ship-based intermediate range ballistic missile, is progressing. Lockheed Aircraft Corp. is the major contractor for the missile. At present, intensive work is being carried out at sea by the U.S.S. Compass Island, which is working on the problem of the precise ocean navigation essential to the success of the project (AW Dec. 10, p. 28).

Jupiter Divorce

The Admiral said Polaris was originally scheduled for "marriage" to the Army's Jupiter project, but the Navy was forced to break the alliance because of its peculiar shipboard handling problems.

He said the projects have been divorced since Dec. 1.

The range of Polaris will be approximately 1,500 mi., putting it in a performance class that is superior to the Regulus II.

FRONT VIEW of display vehicle shows forward stabilizers, which are stationary. Guidance control is achieved through wing ailerons and rudder. Test boom carries vertical and horizontal mounted probes. Rear view of missile, which will be launched from a nuclear submarine now in building stage, shows J79 afterburner. Wingspan is 20 ft.

REGULUS II AIR INTAKE system incorporates a small scoop beneath belly that bleeds off turbulent air. Air exhausts to vents beneath each wing to provide for inlet boundary layer control.

Plan to Subordinate Research Denounced by House Leaders

By Katherine Johnsen

Washington—Congressional opposition to the merger of the Defense Department's research and engineering activities under retired production engineer Frank D. Newbury is growing.

Last week, two leaders took the House floor to denounce the move by Defense Secretary Charles E. Wilson that abolished Newbury's old post of Assistant Secretary for Engineering and the position of Assistant Secretary for Research and Development and combined their functions under Newbury whose new title is Assistant Secretary for Research and Engineering (AW March 4, p. 26).

Rep. Carl Durham (D.-N. C.), chairman of the Armed Services Subcommittee on Research and vice chairman of the Joint Congressional Atomic Energy Committee, called it "the most recent and, in a sense, the most alarming manifestation of the tendency of Secretary Charles Wilson and the Department of Defense to deemphasize research and development."

Cutback Cited

Rep. Melvin Price (D.-Ill.), chairman of the Joint Atomic Energy Subcommittee on Research and a member of the Armed Services Committee, declared that "it is indeed ironic that at a time when military technology is advancing at an unprecedented rate and when our very survival may depend on staying ahead in the field of technology, Secretary Wilson has chosen to relegate research and development to a secondary role in the Defense establishment.

"Not only that, but he has apparently amalgamated the research and development function with the applied engineering function, thereby stifling the effectiveness of both."

Durham and Price singled out the cutback in the aircraft nuclear propulsion program for specific criticism.

Price said that, "if the Department of Defense and the Atomic Energy Commission will not or cannot do the job, there is no alternative for the Congress but to find some organization which can." He suggested the appointment of an administrator "with sufficient authority to get the job done" who would occupy a position similar to that of Rear Adm. H. G. Rickover, director of the naval nuclear propulsion program that produced the Nautilus.

Over the past year, Durham said, the aircraft nuclear propulsion program "has been plagued by indecision and inaction at high levels in the Department of Defense." Noting Secretary Wilson's observation that "a miracle or two" will be required before a nuclear powered aircraft can be built, Durham added:

"The technical part of the program being done by the contractors in the field is progressing well. The place where a miracle is really needed, in my opinion, is inside the Pentagon."

Good Progress

Seconding Durham, Price said that "after a careful study of the nuclear propulsion program and a personal visit to the contractor installations where the actual developmental work is being done, I can say without hesitation that the technical progress is good.

"The main difficulty appears to be in the Pentagon where administrative confusion and indecision over research and development objectives have marked the conduct of the program for the past year. This is a sad commentary on a program which is of such vital interest to future security."

In addition to the research and engineering administrative reorganization, Durham said he is "even more concerned—in fact shocked" over a recent statement attributed to Assistant Secretary Newbury "that no funds of the Department of Defense will be spent for basic research." Newbury's boss, Secretary Wilson, is known to favor restriction of Defense funds to research designed to develop specific hardware, leaving pure research to private industry and universities.

"I can think of no more dangerous course to pursue than to restrict the expenditure of funds for basic research," Durham said. "An action of this kind is tantamount to saying that we have now arrived at a position in our defense which makes unnecessary any further development of any kind. Obviously, this is completely and utterly incorrect. . . .

"We are not engaged in making electric toasters or scooters—we are building, and will continue to build, the most complicated weapon systems and devices that are conceivable at the present stage of our scientific development. We need the best minds, we need ample funds, and we need leadership in this field that has both understanding and sympathy."

Price declared that "it just doesn't make sense to place the former Assistant Secretary of Defense for Applied Engineering, Mr. Newbury, in charge of research and development activities. If we are to maintain our lead in military technology, the first requirement is to have an independent research and development staff, made up of the best scientific brains we can get. This group must be free to encourage exploration of new ideas and reject outdated concepts where necessary. Most important, this group must have vigorous leadership which is not afraid to venture into uncharted fields of technology."

In a letter to Durham, Newbury, who waged a four-year fight to win control of research and development activities, maintained that the criticism is entirely unwarranted. Declaring that "this consolidation was made to increase and not to diminish emphasis on research," Newbury added:

"It is unfortunate that this situation has been interpreted in some quarters as a contest between engineers and scientists, or as evidence of a reduced emphasis on research and that by this organization change engineers have won a victory.

"Nothing could be further from the real reasons back of the change. Neither engineers nor scientists have 'won a victory' over the other. Both, I believe, will be able to do a more important and effective job under the new organization."

Rep. Price plans to study the aircraft nuclear propulsion program at briefing sessions his subcommittee of the Atomic Energy Committee will hold later.

Lockheed Unifies Missile Activities

Lockheed Aircraft Corp. Missile Systems Division will unify all technical activities under a new research and development branch to better facilitate work on several large government programs. Also, a product planning branch has been created and will be responsible for the division's long-range planning activities.

Dr. Louis N. Ridenour, present director of research, will head the new research and development branch for a year and Willis M. Hawkins will become an assistant general manager of the division. At the end of the year, Hawkins, present director of engineering, will take over the branch, and Dr. Ridenour will assume Hawkins' position of assistant general manager of the division. This arrangement will carry on the company's executive training program.

The product planning branch will be under the direction of Wilbur D. Snow, former head of management planning for the corporation. Missile projects at Lockheed include the X-17, the X-7 and the Polaris.

Plasma Jet Controlled in Test Tunnel

New York—General Electric Co. Missile and Ordnance Systems Department, has developed a controlled environment tunnel to increase and refine the capabilities of the plasma or atomic jet. This is vital to future aerodynamic heating studies and the plasma jet may be a source of power for space flight.

The plasma jet operates continuously at twice the surface temperature of the sun and produces the highest steady-state heat transfer rates ever accomplished experimentally.

This jet of highly ionized gas is generated by an electric arc confined within a whirling sheet of water allowing greater current flow and higher temperatures.

The water is vaporized into an atomic state of disassociated particles and this plasma is extracted from the arc through a nozzle and directed at a test specimen.

The specimen is then subjected to velocities up to 4,000 ft. per sec. and heat transfer rates of 2,000 Btu/sec. ft.^{2} about four diameters from the nozzle. This compares with 800 Btu/sec. ft.^{2} from rocket engine nozzles. Materials and general shapes may be tested in this manner.

The GE tunnel is an evacuated chamber containing the specimen, and permits close control of the size and rate of plasma flow, and thus, more accurate simulation of a given environment.

Giannini Research Laboratory, Santa Ana, Calif. is also working with a stabilized arc and is developing a low density tunnel. Its related projects include an AFOSR contract to study the principles of high energy, ionized gas flow, basic to ion propulsion proposed for space travel.

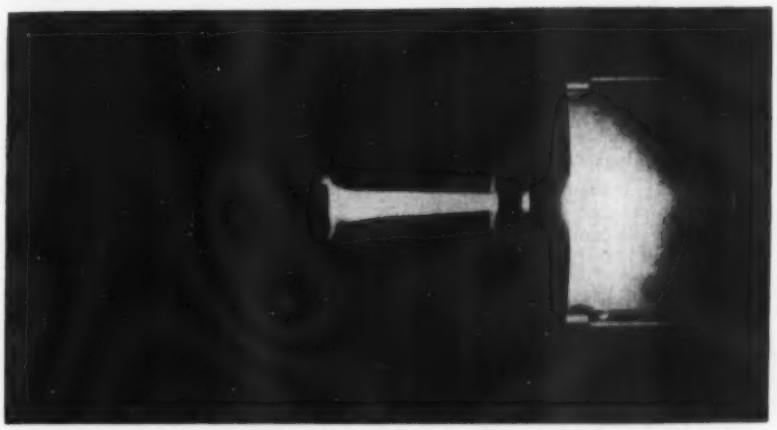
These studies will also determine the feasibility of the stabilized arc for propulsion use.

The University of Chicago's Midway Laboratories have worked closely with GE on the water-stabilized arc. They developed the geometry of the arc chamber and manner of extracting the plasma from information published by the University of Kiel, Germany.

The plasma jet is superior to other experimental heat sources besides providing higher heat transfer rates. It allows erosion and ablation studies which cannot be accomplished in the solar furnace, and its cost is one-tenth that of rocket engine tests.

The stabilized arc is in its early form. Air-stabilization, now under development, promises velocity increases to 10,000 ft. per sec., and the use of inert gases will widen the range of possible environments.

GE TUNNEL is heavy pressure vessel with glass enclosed arc mounted on end plate.



PLASMA JET is shown venting to the atmosphere against test specimen. High velocity water stream is whirling inside glass.

CLOSE-UP of material test shows specimen receiving blast of ionized gas.

Aircraft Industry Reports Record Earnings and Sales, Rising Costs

New York—Record earnings and sales, plus rising costs, were trends notable in 1956 annual financial reports in the aircraft industry.

Ralph J. Cordiner, president of General Electric, set the keynote for most other company heads in their statements to stockholders when he said one of the principal factors limiting earnings was the high level of extra costs.

In GE's case another factor was a slump in electrical appliance business, but Cordiner also blamed the "high level of extra costs associated with the record expansion of facilities and the continued high levels of expenditures for research and development work."

GE sales for 1956 totaled a record $4,090,015,685 for an 18% jump over 1955's $3,463,734,419. Earnings hit a record $213,756,849, but this was only a 2% increase over 1955's $208,908,054 earnings.

Among top industry corporations—United Aircraft, Douglas, Boeing, Curtiss-Wright and General Dynamics—all reported record years for 1956 of more than $30 million in profits.

Curtiss-Wright's net income of $43,153,518 was especially remarkable in the light of its 1956 sales of $571,064,793, far less than the billion dollar sales of other top companies which returned less in earnings. Earnings in 1955 were $35,081,045 on sales of $508,703,445.

United Aircraft reported 1956 net income of $37,082,493 on sales of $952,885,142 compared to 1955 income of $31,064,924 on sales of $697,347,921,704.

H. M. Horner, chairman of United, and William P. Gwinn, president, said expenditures for additional facilities were approved for 1957 totaling about $90 million, most of which was slated for Florida.

Another item brought out in the United report was the projected use of Pratt & Whitney J75 15,000 lb. thrust engines for the Martin P6M SeaMaster.

The airplane previously had been committed to Allison J71 10,000 lb. thrust engines.

United reported a backlog of $2.3 billion at year's end, a substantial increase over the $1.4 billion of the year before.

Douglas Earnings

Douglas Aircraft reported highest sales in company history—$1,073,515,000—missiles accounting for 13% or $140 million. Donald W. Douglas, president of the company, said this missiles percentage "will continue to mount at an accelerated pace. . . . It is clearly evident that there is developing an increased emphasis in our national defense planning on pilotless planes, missiles and rockets."

Net earnings for the fiscal year ended Nov. 30, 1956, were $33,202,000, compared with $28,215,000 in 1955.

Douglas recently issued $27,900,000 of 4% convertible subordinated debentures which were sold out as soon as the bonds hit the market.

The money is for capital needs and expansion.

General Dynamics

General Dynamics, holding company for Canadair and the Convair Divisions, also had a record year. The company, whose annual report will not be out until late this month, had a net income for 1956 of "nearly $32 million," a big increase over 1955's $21,254,386.

President John Jay Hopkins, in announcing a 1 for 1 stock split, said sales for 1956 more than doubled 1955's $687,274,182. Common stock of the corporation would be increased from 15 million to a total 30 million shares.

The decision will be submitted to shareholders at the annual meeting scheduled for April 25.

Boeing

Boeing rolled up record earnings of $32,134,989. Sales rose to $1,006,356,748 in 1956 compared with $853,827,722 in 1955. Earnings in 1955 were $30,391,411.

Boeing said the principal reason for the reduced return on sales was a writeoff of certain research, developmental and general expenses. The company said it planned to appeal as unjustified the renegotiation board's request for a refund of $2,057,793 on what the board said were excess profits of $7,500,000 in 1953.

Ford

Ford Motor Co. earned $236.6 million in 1956 compared with $437 million in 1955, mostly as the result of sales of motor cars. However, sales of defense products were $273 million compared with $259 million in 1955, largely represented by the Pratt & Whitney J57 jet engine.

Backlog of orders for defense products at year's end was almost $1 billion, including an initial order for the Pratt & Whitney J75.

H. J. McGinn and John C. Virden, chairman and president respectively of the Eaton Manufacturing Co., called the "continued inflationary spiral and encroachment of rising costs upon profits . . . national problems facing the whole economy and country."

Eaton's earnings declined in 1956 to $12,980,028 from 1955's record high of $13,285,496. However, sales of the company's 16 divisions and two subsidiaries had increased to $227,196,703 in 1956 compared with 1955's $218,116,159.

Avco Loss

Avco Manufacturing showed a net loss of $16,387,847, largely as a result of losing operations in its Bendix laundry equipment and Crosley appliances, radio and television divisions.

Backlog of defense orders, including research and development, Lycoming engines, fire control systems, airframe components and assemblies, is $340 million, a 70% increase over the $200 million at the end of the 1955 fiscal year.

Strike Woes

Two other companies hit by the cost situation, in addition to strike woes, were Westinghouse and Solar Aircraft.

In the first half of its current fiscal year, the six months ended Oct. 31, 1956, Solar had a net loss of $199,800. However, earnings in the following quarter, ending Jan. 31, 1957, practically offset this, the loss being reduced to $1,300.

Solar's sales for these nine months, including a $12.2 million order for J57 turbojet engine components, totaled $31 million. As of Jan. 31 Solar's backlog was a record high of $94,826,700, compared with $72,180,000 a year earlier, and the company recently voted a quarterly common stock dividend of 25 cents a share payable April 15.

Westinghouse, plagued by a long strike, cased its comeback somewhat by instituting the LIFO (last in, first out) method of inventory evaluation whereby inventory is pegged at present prices rather than prices actually paid when goods were bought.

LIFO Explanation

Gwilym A. Price, Westinghouse chairman, told stockholders this method reduced income taxes and the company's reported book profits during periods of rising costs of labor and materials. Thus, the 1956 net income, $15,537,000 before LIFO, was listed as $3,492,000 on the books. Westinghouse net income in 1954 was $79,921,732 and in 1955, $42,802,747.

Net sales for Westinghouse for 1956 increased 6% over 1955 for a total of $1,525,375,000. Price said 1956 fourth quarter sales of $500 million were the

highest in the company's history but "recovery of profits" was not at a comparable level due partly to abnormal expenses and goods being shipped that were sold in 1955 at "unusually low prices."

Other reports of earnings:

• **Net income** of Radio Corp. of America was $40,031,000 on sales of $1,127,774,000, a record for the company. Profit in 1955 was $47,515,000 on sales which were 7% less than in 1956.

• **Ryan Aeronautical Co.** made $1,256,769 on sales of $46,998,925 in 1956 compared with $1,550,590 on $41,527,770 in 1955.

• **National Aeronautical Corp.** reported a 65% increase in net income—$199,000 on $2,513,000 sales in 1956 compared with 1955's $120,000 on $1,620,000 sales.

• **Aro Equipment Corp.** earnings in 1956 were $1,193,462 compared with $1,107,416 in 1955.

• **Rohr Aircraft** 1956 earnings for six months ended Jan. 31 were $1,717,773 compared with $1,312,350 for the same period last year. Backlog is $216,639,000 compared with $144,736,000 a year ago.

• **Net earnings** of Consolidated Electrodynamics Corp. were up 60%, $1,283,263 in 1956 to $803,696 in 1955.

• **Pacific Airmotive Corp.'s** net profit was $921,420 in 1956 compared with a net loss of $8,378 for 1955.

• **Net income for** Rem-Cru Titanium, Inc., jointly owned by Remington Arms Co. and Crucible Steel Co., declined to $54,000 in 1956 from $896,000 in 1955 due primarily to production losses from two serious furnace explosions and two strikes.

• **Reaction Motors'** earnings were $348,348 in 1956 compared with $192,866 in 1955. Sales were $166,193,944 and $7,522,958 respectively.

• **Continental Motors Corp.** reported net income of $909,978.48 in the 1957 first quarter ending Jan. 31, including a non-recurring profit item of $150,700.10. Net earnings in the same period in 1956 fiscal year were $243,638.43.

Dividends and other corporate reports included:

• **Northrop Aircraft, Inc.,** declared a 40 cents quarterly dividend payable March 23.

• **American Bosch Arma Corp.** authorized a dividend of 25 cents a share payable April 15; also a $1.25 per share dividend April 1 on 5% cumulative preferred stock series A & B $100 par value.

• **Radio Corp. of America** declared a quarterly dividend of 25 cents a share payable April 29 on common stock, a dividend of 87½ cents on first preferred stock for the period April to June 30, payable July 1.

• **Glenn L. Martin** authorized quarterly dividend of 40 cents payable March 27.

• **Chance Vought** announced a dividend of 40 cents a share payable March 29.

• **McDonnell Aircraft** declared a dividend of 12½ cents payable April 1.

• **North American** authorized a 40 cents a share dividend for stockholders of record March 15.

• **International Business Machines** declared a second quarter dividend of 60 cents a share, including shares in a 1-1 stock split subject to stockholder approval April 30. It would be payable June 10 to stockholders of record May 21. Purpose of the split is to raise $200 million in captal funds.

USAF Begins Procurement Officer Shift

By Claude Witze

Washington—First of an extensive series of assignment changes for top USAF procurement and production officers will take place this summer.

The planned shift of Maj. Gen. David H. Baker from the Air Materiel Command to a new post as assistant for programming in the office of the Deputy Chief of Staff for Operations at the Pentagon leads a list of seven reassignments announced last week.

Before the end of the year other top personnel probably will be shifted to new procurement posts, both at headquarters and Wright-Patterson AFB, Ohio.

There is a strong possibility that Lt. Gen. Clarence S. Irvine, deputy chief of staff, materiel, will replace Gen. Edwin W. Rawlings as commander of the Air Materiel Command. Speculation now is that Gen. Rawlings will be sent abroad to take over a foreign assignment.

Possible assignments mentioned for Gen. Rawlings are commander of USAF in Europe, replacing Lt. Gen. William H. Tunner, and commander of USAF in the Far East, replacing Gen. Laurence S. Kuter.

Gen. Kuter is being mentioned as a candidate for USAF chief of staff, replacing Gen. Nathan F. Twining, who is expected to become chairman of the Joint Chiefs of Staff. Another prominent candidate for the top USAF position is Gen. Earle E. Partridge, commander of the Air Defense Command.

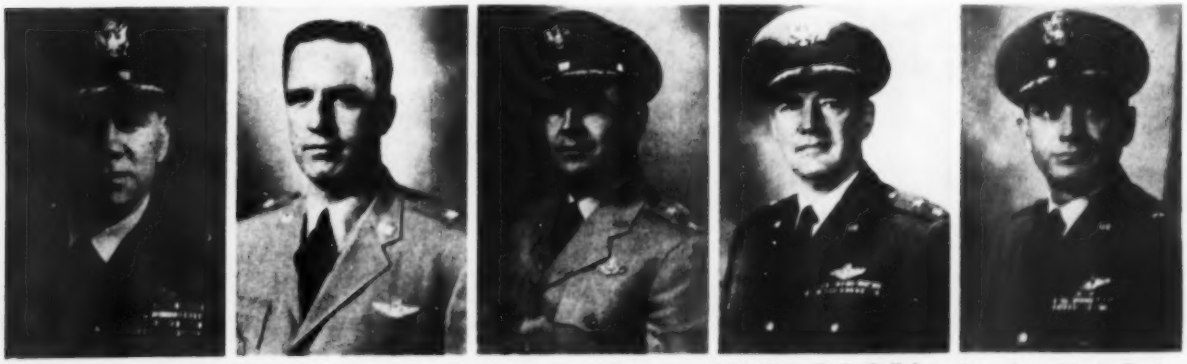
Last week's changes for Gen. Baker and six other officers came as a surprise to some Air Staff members in the Pentagon.

The new assignments, effective in August, include:

• **Maj. Gen. William O. Senter,** commander of the Oklahoma City Air Materiel Area, will replace Gen. Baker as director of procurement and production at the Air Materiel Command.

• **Maj. Gen. Thomas P. Gerrity,** assistant for production programming in the office of the Deputy Chief of Staff, Materiel, will become commander of the Oklahoma City AMA.

• **Brig. Gen. Waymond Austin Davis,** director of procurement and production in the office of DCSM, will replace Gen. Gerrity.



Maj. Gen. D. H. Baker | Maj. Gen. W. O. Senter | Maj. Gen. T. P. Gerrity | Maj. Gen. D. F. Callahan | Brig. Gen. W. A. Davis

This position, as assistant for production programming, was created at headquarters by Gen. Irvine when he became DCS/M.

• **Maj. Gen. Daniel F. Callahan,** assistant for programming, office of the Deputy Chief of Staff for Operations, will become commander of the Mobile AMA, replacing Maj. Gen. Fred R. Dent, Jr.

• **Brig. Gen. Laurence B. Kelley,** deputy commander of Mobile AMA, will be director of logistics plans in the office of the DCS/M.

• **Brig. Gen. Donald L. Hardy,** chief of the Air Force Section, Military Assistance Advisory Group, Tokyo, will replace Gen. Kelley at Mobile AMA.

Gen. Senter, who will replace Gen. Baker at AMC, has been a pilot since 1934, a year after his graduation from West Point.

Three years later, he took a meteorology course at Massachusetts Institute of Technology and spent his entire career in weather officer positions.

He was chief of the Air Weather Service at Andrews AFB, Md., when assigned to the Oklahoma City AMA in May 1954.

With the shift of Gen. Baker to a job in operations, the aircraft industry will lose contact for the most part with a man who has gained wide respect in his term at AMC. He is a graduate of the Harvard School of Business in addition to West Point. At AMC since 1951, he served there as director of command support and comptroller before his appointment as Director of Procurement and Production.

Gen. Gerrity is a veteran officer in materiel with experience in this field reaching back to 1942, when he was removed from combat in the Pacific to join the Air Materiel Command. He has had wide contact with the industry, serving as a project officer, chief of the bombardment branch and the aircraft and missile section.

Vertol Plans Commercial H-21

Morton, Pa.—First two airworthiness certificates for commercial versions of Vertol Aircraft Corp.'s H-21 tandem helicopter are expected by mid-April.

The program for Civil Aeronautics Administration certification of the H-21 is being conducted jointly by Vertol and the Canadian Department of Transportation. The company took this path to the commercial market at the request of the Royal Canadian Air Force, which has been operating H-21s for approximately three years. The RCAF is considering a contract operation, turning its helicopters over to a commercial firm for flying and maintenance.

Commercial version of the H-21 will be called the Vertol 43 Work Horse. It will be the first U. S.-built transport helicopter to compete with designs by the Sikorsky Division of United Aircraft Corp. in the civil market. Sikorsky has been selling commercial helicopters for approximately 10 years.

Already in military service since 1952, the H-21 will be certificated to operate at 14,000 lb. gross weight. Initially, it will be equipped with wooden blades, but the company expects to replace these with metal blades before the end of 1957.

Modifications

Major modification of the H-21 is the incorporation of stability improvements, including larger vertical fins on the tail stabilizer. These have been increased in area by approximately 25% for better directional stability.

Other changes required for certification:

• **Fire protection** in the engine compartment.

• **External lighting changes.** The landing light has been moved forward, and the flashing sequences changed to commercial standards.

• **Irreversible control actuators** to eliminate shake in controls with boost off.

• **Electrical system changes.**

• **Improved throttle synchronization.**

• **Soundproofing.**

• **Larger windows,** hinged doors.

Turbine Version Planned

The first Vertol 43s will be powered with the conventional Wright R-1820-103 piston engine with a takeoff rating of 1,425 hp. Later, the company will seek certification of a turbine-powered version carrying two General Electric T58 engines. Initial installation of these units is being carried out under military contract, and the prototype will be ready for ground tests some time in May.

Vertol's long-awaited certification of the military H-21 comes at a time when commercial operators are becoming increasingly critical of U. S. helicopter manufacturers for their alleged failure to carry out earlier promises. Last September, Robert L. Cummings, Jr., president of New York Airways, said his company may look to Europe in its search for satisfactory multi-engine equipment.

Test Program

Three aircraft are being used in Vertol's certification program. One of them belongs to the RCAF, the other two to the company. All are being flown at Vertol's flight test facility at Philadelphia International Airport.

One helicopter is used for rotor strain tests, the others for work on stability, throttle synchronization, lighting, carbon monoxide and irreversible actuator tests.

In addition to metal blades, other changes to be made in the future include the incorporation of additional stability devices, a lower horsepower cooling fan and a new air induction system.

The first certificated H-21s are expected to be delivered to the French government and will be exhibited at the Paris Air Show in May. At that time, the company will publish estimated operating costs.

Vertol Discharges 61 Engineers

Morton, Pa.—Vertol Aircraft Corp. last week discharged 61 engineers and 109 technical and office employes in the engineering division. The company said the layoff was required by completion of detailed engineering designs on major current projects.

A leading helicopter supplier to the armed services with growing sales abroad in France, Germany and Canada, Vertol still has no substantial orders on the books for production in calendar 1958 and later. U. S. Army cutbacks resulted in cancellation of plans to purchase follow-on quantities of the H-21C (AW Jan. 14, p. 30). In addition, the Vertol design for a Navy utility helicopter lost out in a close race to the Kaman HU2K-1 in a recent competition. (AW Feb. 11, p. 34).

Vertol has plans to enter the commercial market with a certificated version of the H-21 and is taking part in other design competitions. It is a strong contender in the joint Army-Navy proposal for a higher performance observation aircraft. It also is building a tilt-wing VTOL test bed for the Army and is entered in three other Army competitions for a flying jeep, a flying crane and a multiple-helicopter lift proposal. The company also has submitted a proposal in a current USAF competition for a rescue helicopter. Several weeks ago, Vertol announced it is taking over a 300-acre site near Philadelphia for future plant expansion. Recent negotiations for a merger with Northrop Aircraft have been abandoned (AW Feb. 25, p. 352).

NEW from EEMCO

A 400 Cycle AC Linear Actuator with an operating range of 320 to 480 cycles

SPECIFICATIONS FOR TYPE D-818

Normal operating load: 6000 pounds
Maximum operating load: 12,000 pounds
Ultimate static load: 24,000 pounds
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Rate of travel: .33 inches per second
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Qualification: Type D-818 has been designed and qualified to meet applicable military and aircraft manufacturers' specifications.

EEMCO 400 cycle linear actuator **Type D-818** is being installed as a leading edge flap actuator in the latest and fastest supersonic fighter aircraft now being produced for the U. S. Air Force.

Incorporated in the **EEMCO** motor in **Type D-818** is a torque-limiting AC clutch which disconnects the high inertial load imposed by the motor's armature. A brake can be built into this mechanism if **Type D-818** is altered for use in another capacity. Adjustable non-jamming stops are included which are especially convenient when the airplane is being rigged.

One of its outstanding features is that it operates on a frequency range of 320 to 480 cycles, versus a normal range of 380 to 420 cycles. This eliminates need for a constant speed drive for the airplane's generator system, thereby saving maintenance of same as well as considerable cost and weight.

EEMCO is a specialist in the design and production of precision-built actuators and motors. The majority of the latest and fastest aircraft and missiles being produced for the U. S. Department of Defense carry one or more **EEMCO** systems. Industry, too, is using **EEMCO** linear and rotary actuators where precise control of mechanical actuating systems is imperative.

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HYDRO-AIRE

British Withdraw Gyron Support

London—Britain's economy-minded government is canceling its support of the de Havilland Gyron A turbojet engine, which has been running on a test bed at 25,000 lb. static thrust with afterburner.

A Ministry of Supply official says financial support for the supersonic engine "is due to end shortly and is unlikely to be renewed." The government attitude was made known shortly after it was revealed the Gyron is rated without afterburner at 20,000 lb.

A de Havilland spokesman said the company will carry on with the development of the Gyron as a private venture. He termed it an "outstanding engine with great potential uses" and disclosed that both the United States and France are interested.

Cancellation indicates there are no projects using this engine which will continue to have financial support from the Ministry of Supply.

Although no application for it had been revealed, de Havilland had suggested that the engine might be adapted to a supersonic bomber, a cruise missile or an air-to-air missile carried by a piloted interceptor. Avro has a supersonic bomber under development. Whether cancellation of the Gyron means cancellation of the bomber or whether another engine is specified, as the Bristol Olympus, was not clarified.

De Havilland said the Gyron's first development stage running at 25,000 lb. thrust with afterburner is the highest yet announced for any engine in the world.

The company said the Gyron was designed for optimum efficiency in aircraft flying up to Mach 3. De Havilland believes it is the only supersonic turbojet that has reached such a state of development.

Particular attention was paid to intake problems and the firm says its technicians have achieved "remarkable progress" on intake design.

Ground and flight trials have been carried out over a wide range of speeds and altitudes, with and without afterburner, and with a variety of propelling nozzles. Flight tests were made in a Short Sperrin bomber. In this aircraft, the engine has been approved up to 18,000 lb. static thrust.

More than 2,600 hr. of bench running have been logged.

The government decision returns the engine to its former status, for it was started as a private project by de Havilland six and a half years ago. It passed its government type test at 15,000 lb. static thrust in August, 1955.

De Havilland says that in addition to its ability to operate at high supersonic speeds, the engine possesses a useful endurance and capability for high-altitude operation.

Rather than a blow at the engine itself, the government's decision to drop support of it more likely reflects decisions against projects which would have used the engine. It is known that Defense Minister Duncan Sandys is applying the ax to a number of advanced projects in the government economy drive.

News Digest

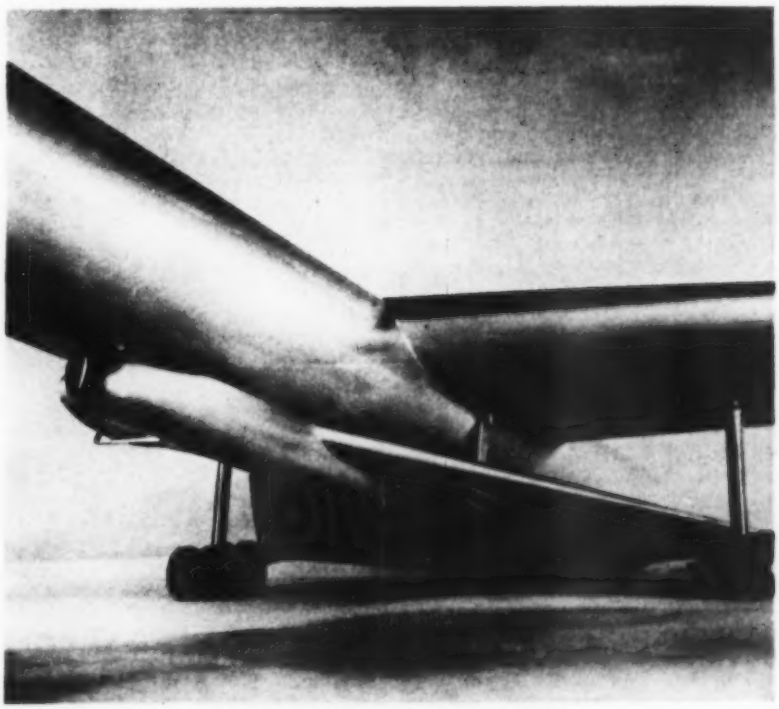
Sperry Gyroscope Co. Air Armament Division will develop high-precision missile devices using liquid and solid propellants in small, self-driven instruments. Sperry plans to produce them at its plant at Great Neck, N. Y., and is completing laboratory there for testing hot gas servos, gas generators, propellant driven gyroscopes, mechanical actuators, arming devices, etc.

Harold E. Talbott, 68, former Secretary of the Air Force, died of a heart ailment on March 2. Air Force Secretary for a little more than two years, Talbott resigned in August, 1955, after congressional questioning on a possible conflict of interest between his Pentagon job and his partnership in the New York engineering firm of Paul B. Mulligan & Co.

Fiat G 91 prototype crashed two weeks ago. Pilot, who ejected, saw the fighter disintegrate in air. On order by NATO, G 91 last month made four supersonic runs at altitudes above 30,000 ft.

Martin Nuclear Division will receive approximately 65 kg. of uranium hexafluoride for processing into 50 kg. of uranium dioxide. After fabricating into tubular fuel elements, fuel will be used in a 1,000-2,000 kw. air transportable power plant Martin is developing.

Lockheed Aircraft Corp. plans to construct a nuclear facility for critical experiments at Palo Alto, Calif. AEC approved facility, which differs from reactor in that fuel assembly and other components are not permanent, but may be rearranged easily. Lockheed plans primarily to test reactor cores at the facility.



B-36 Will Carry B-58

Model shows how B-36 will carry B-58 from Convair's Ft. Worth, Tex., plant to Wright-Patterson AFB next month for static tests on B-58 airframe. Two inboard propellers of the B-36 will be removed and it will make the 950-mi. flight on its remaining four piston engines and four jet engines. Landing gear on the B-36 must remain down throughout. Airlifting the B-58 will be cheaper than flying B-58 there and shipping engines back.

Capital Reveals Viscount Operating Costs

Airline summary released to Aviation Week shows costs stabilizing; Capital foresees profit in 1957.

By L. L. Doty

Washington—Capital Airlines has disclosed for the first time maintenance and cost figures for its scheduled turboprop Viscount operations.

In a summary released to AVIATION WEEK of the 12 month period ending last November, the airline reports that operating costs are stabilizing in an area approximately midway between DC-3 and DC-4 costs. Total operating expenses already have declined to a level which Capital believes will mean the difference between the 1956 $1.8 million net loss and a 1957 profit.

Viscount Record

Here's how the Viscount record stands for the 12 month period:

- **Total miles flown** during the period were over 15 million. Total hours flown on a takeoff to touchdown basis totaled 62,393. The latter figure includes 3,132 hours of non-revenue flying, the majority of which involved pilot training.
- **Available seat-miles** amounted to 641.8 million; available ton-miles, 80 million. Increased mileage introduced as a result of new routes held the load factor at 63% for the 12-month period.
- **Revenue passenger-miles** came to 403.8 million, total revenue ton-miles reached 41.5 million, and the weight load factor was 52%.
- **Average length of each flight** was 321 miles flown in an average time of one and one-half hours at a takeoff to touchdown speed of 246 mph. Number of revenue flight legs flown during the period totaled 45,458.
- **Fuel consumed** averaged 437 gallons per hour. The Viscount has a total capacity of 2,300 gallons with full payload.

Cycle Not Complete

Capital did not reach a complete operating cycle of a full-fledged fleet during the period. The 60th Viscount of the original order is scheduled to arrive this month.

Company engineers and accountants say, however, that experience gained with this fleet is sufficient to serve as a standard for future planning. It also gives them their first gauge by which they can measure turboprop costs in relation to traditional costs.

Now, with the heavy introductory costs resulting from training and retooling out of the way and with an established break-even load factor of less than 55%, officials say total operating costs will decline in proportion to the addition of Viscounts to the fleet. But direct maintenance costs probably will rise as more Viscounts move into the overhaul cycle.

Capital has taken delivery on 292 Rolls-Royce Dart engines to date. First of the airline's Viscounts were powered with the Dart 506 engine, which has a rating of 1,400 shp. Later aircraft were equipped with the more powerful Dart 510 engine, which has a 1,600 shp. rating, and the balance of the fleet is now being converted to the newer powerplant.

The progressive system of engine overhaul has been adopted, and Capital tries to stagger engine changes so that no more than two engines are removed from any one Viscount at a time.

Although continuing improvements are being introduced into the engine overhaul system, basic procedures have evolved. For example, manhours per engine overhaul have been cut from an average 1,183 in January, 1956, to 486 in October. Accessories overhaul manhours have remained fairly steady at about 73 manhours per engine.

Engine Overhaul

Engine overhaul interval has climbed to 1,500 hours from the 700 hours originally authorized when the Viscounts were first placed into scheduled service. Capital's goal is 2,000 hours but, since the Civil Aeronautics Administration restricts each 100 hour increase to once every three months, it will be at least another year before the goal is attained.

The Curtiss-Wright 3395BA3 engines on Capital's Lockheed Constellation 049s have an overhaul interval of 1,300 hours and require 600 manhours per engine.

Both Trans Canada Air Lines and Capital were held to 725 hours overhaul time on the first stage compressor and combustion chambers even after engine overhaul time had been authorized at 1,400 hours.

A stiffening rib was installed on the rear of the compressor and heavier metal was introduced, modifying the natural frequency, to raise the unit's overhaul time to that of the engine. The combustion chamber lag in overhaul time was cut by replacing the wasp-waist design of the flame tubes with a straight center and by installing dual cooling strips.

Both units are now at the 1,500 hour stage of overhaul.

Each engine requires 10 elapsed days for complete overhaul from the time it is taken off the line to its return to service. During January, 61 engines were processed; 30 were completely overhauled, and 31 were modified with the redesigned first-stage compressor.

Direct maintenance costs for the Viscount during the 12 month period totaled $33.86 per hour, or 13.7 cents per mile. On a mileage basis, flying operations costs were 39.1 cents, depreciation 21.5 cents, for a total direct operating cost of 74.3 cents with 15.8 million miles flown.

Maintenance Expenses

Hourly direct operating expenses averaged $183.48 for the period, with 64,091 hours flown exclusive of training hours and costs. This is how direct maintenance expenses break down for the 12 month period:

- **Labor-aircraft**—4.1 cents per mile, or $10.04 per hour.
- **Labor-engines**—2.3 cents per mile, $5.65 per hour.
- **Labor-other**—1.1 cents per mile, $2.80 per hour.
- **Material-aircraft**—2.2 cents per mile, $5.57 per hour.
- **Material-engines**—3.4 cents per mile, $8.32 per hour.
- **Material-other**—.6 cents per mile, $1.48 per hour.

Depreciation costs are expected to decline as utilization increases. However, direct maintenance costs may settle at a higher level when the full cycle of engine and airframe overhaul is reached. As one Capital official explained, "We get a free ride with each new airplane as far as overhaul costs are concerned."

Operating Efficiency

The Viscount has maintained a 95.4% operating efficiency. At present, total costs—including depreciation, station costs, overhead and all direct and indirect expenses—are covered by a load factor below 55%. Improved utilization is expected to reduce this figure further.

Only 19% of the mechanical delays have been attributable to powerplant malfunctions as compared with almost 57% for the Lockheed 049s. Average mechanical delay on the Viscounts has been 26 minutes as compared with an

average delay of 53 minutes on all piston engine aircraft.

During the last four months of the period, the airline operated 143,000 Dart 510 engine hours without one engine failure. Aircraft utilization for the 12 months was 8.12 hours per day.

Capital's overhaul shop at the Washington National Airport has been redesigned to contain two parallel assembly lines, one to handle turboprops, the other for piston engines. Neither line is interchangeable with the other at any stage of overhaul, tear-down or reassembly, with the exception of the cleaning section where the lines converge because cleaning processes of some parts are alike.

Whether the Rolls-Royce Avon engine which will power the 14 de Havilland Comet 4As ordered by Capital can be merged with Dart engine overhaul at any, or all, stages has not yet been determined. However, engineers studying this possibility feel there is little possibility of much overhaul integration, because of the greater power and thrust and the more complicated character of the turbojet engine.

But, in any event, they feel experience gained with the Dart will expedite the introduction of the Avon into overhaul practices and will enable the airline to bypass many of the high transitional costs that accompanied the change-over from an all-piston operation. The engineers also hope to lay out Avon engine overhaul facilities well in advance of the first Comet deliveries scheduled for late 1958 or early 1959.

Dart Subassemblies

Dart engines are torn-down in three subassemblies:

- **Reduction gears** and air intake.
- **Compressors.**
- **Turbine and combustion chambers.**

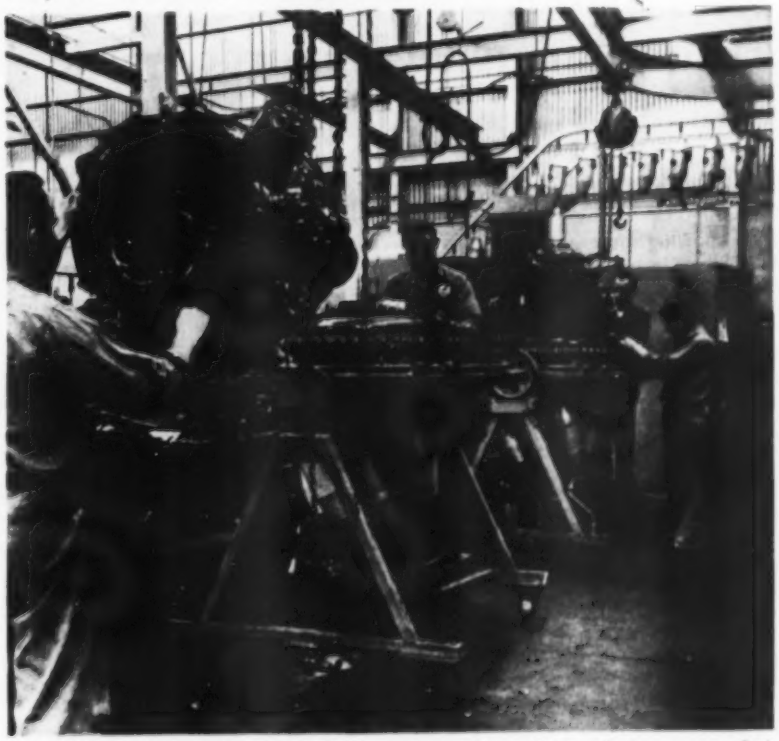
Parts of each subassembly are loaded in metal baskets that are moved to the shop's cleaning section on steel roller conveyors.

Capital has devised its own cleaning methods for turbine blades and wheels. Originally, the units were cleaned with vapor blast followed by electro polishing, but it was found that this system was removing base material and reducing the life of the units. Now the airline employs a commercial cleaning process known as Turco 4008 with excellent results.

Turbine discs are now processed by electro-cleaning followed by inspection with 10-power binoculars. Here again, base material is lost in the cleaning process, and plans are being completed to adopt the Turco 4008 system using Magnaflux Magnaglo for inspection. All other magnetic parts are inspected by Magnaflux and all non-magnetic parts are inspected by die-check.

Impellers are stripped and run

CAPITAL runs its Viscount Rolls-Royce Dart engines in this hangar test cell. A new building has been constructed to house cells for both the Dart and the Rolls-Royce Avon which will power the Comet 4s on order by the airline.



TURBINE engine overhaul shop is divided into three subassemblies: reduction gears and air intake; compressors, and turbine and combustion chambers. Here is final reassembly of the subsections. Combustion chambers are on ceiling conveyor belt at rear. Whether overhaul line for Avon turbojet engines in Comets can be integrated with Dart line has not been determined.

through the replating section where they are reanodized for protection against corrosion. This process has not entirely eliminated minor corrosion problems on the second-stage impeller, and Capital is now service testing impellers that have been coated with transparent phenolic resin in hopes of stopping all corrosion.

After cleaning and inspection, subassemblies are moved to the assembly line on mobile metal cabinets or shelves of Capital design. Plans call for the extension of the steel roller conveyors into the subassembly areas.

Combustion chambers move to the final assembly area on ceiling conveyors from either the inspection section or from the machine shop if replacement of center casings is necessary.

Turbine blades get individual inspection. Blades are weighed to within one-tenth of one ounce on a Gisholt 2U balancing unit after inspection. They are installed so that weights are staggered. The heaviest blade is fitted at 360 degrees on the wheel, the next heaviest at 180 degrees, then next at 90 degrees, etc. Turbines have caused no major operating or overhaul problems for the airline.

Special strip-and-build stands have been designed by Capital for the Dart engine overhaul. Each stand is set on dollies to permit movement of the engine through each stage of subassembly to final assembly. The engine is assembled on the stand nose-up but, because the stand frame is hinged to the main supports on swivels, the engine can be adjusted to a horizontal position when necessary.

The circular frame rotates 360 degrees on the stand, eliminating the need for mechanics to walk around the engine while working. Fully assembled engines are moved on the stands from the final assembly area to the test cell.

Because of lack of space, Capital has only one test cell within its hangars. This cell is equipped to handle the Dart. Converted city buses with instrument chambers in the front half of the bus and engine stands on the open back are used for piston engines and Dart engines overflowing from the hangar.

Construction of a new building on the boundary of the airport to house two more cells is almost completed. One cell will be used for the Dart, the second will be reserved for the Avon.

All shop training is now accomplished on-the-job. Originally, mechanics and engineers were trained by Rolls-Royce in England or by Trans Canada. Later, two-week class studies were conducted, but the overhaul process has now advanced far enough to permit on-the-job training to eliminate another costly aspect of the turbine operation.

Airline Financial Reports Spark House Criticism of Fare Plans

By Ford Eastman

Washington—Airline financial reports showing increases in net income touched off congressional criticism last week of the growing number of applications for a general fare rise.

Rep. Charles A. Vanik (D.-Ohio), in a speech indicative of increasing Capitol Hill opposition to any increase, pointed specifically to Eastern Airlines' published report that it earned $14,197,500 in 1956 as compared with $9,342,791 in 1955.

'Gratitude for Favors?'

A proposed 6% fare increase by Eastern and five other carriers, Vanik charged, "is the response of the airlines to the current drive to slow down the spiral of rising prices. This is the gratitude to government for the granting of what are, in effect, monopoly airline routes throughout America." He later added:

"In view of the tremendous public contribution to the operations of the domestic airlines by the way of franchise, airport and control tower operation and accelerated depreciation, no American industry has a greater obligation to hold the price line than the domestic airlines."

Vanik conceded that wages, the price of fuel and other materials have increased since the last fare boost in 1952 but said airline passenger-miles have grown by almost 100% during the period.

"If," he said, "the Civil Aeronautics Board will compare the passenger-mile cost in 1952 with the passenger-mile cost in 1956, this comparison will disclose that passenger-mile costs have not increased sufficiently to warrant any increase in airline passenger fares."

In support of the need for a fare increase, the Air Transport Assn. has filed a series of exhibits with the CAB pointing out that railroad passenger fares have increased 30% and bus passenger fares 27% since 1938. General airline fares, on the other hand, have shown an increase of less than 3%.

The exhibits also emphasized the higher quality of air transportation today, including pressurized cabins, weather radar, greater speed and coach service. The number of cities served, the ATA said, also has been increased.

ATA said another factor pointing to the need for a fare increase is the fact that the cost of parts and equipment has climbed more rapidly than prices generally.

As an example, the ATA cites a DC-3 engine, which costs $10,000. Two are required per airplane. Modern four-engine aircraft require power plants costing as much as $75,000. Pre-war DC-3 airframes cost $85,000, or $6 a pound, as compared with airframes of today's airliner which cost $1,450,000, or $29 a pound.

Stuart G. Tipton, ATA president, said the airlines have been able to offset rising prices to some extent by increased efficiency of operations. But in recent years, he said, cost trends have grown to a point where the airlines' ability to absorb higher prices is nearing an end.

Eastern Airlines' financial statement referred to by Vanik was a preliminary report to the board of directors.

Earnings Breakdown

The unaudited figures reported net income from operations at $14,197,500, or $4.98 per share, as compared with $9,342,791 or $3.73 a share, in 1955. Non-recurring net income for 1956 was placed at $537,900, as compared with $3,966,706 for 1955. The number of shares outstanding at the year's end had increased to 2,849,816 from 2,504,127 on Dec. 31, 1955, primarily because of the purchase of Colonial in 1956.

Eastern's gross operating revenues totaled $228,040,200, a 14% gain over the 1955 total of $198,608,302. At the same time operating expense increased from $172,083,597 in 1955 to an all-time high of $199,610,360 this year, an increase of 16%.

In another report last week, United Airlines listed 1956 net earnings at $14,681,000, the largest in company history and 31% above the $11,245,000 for 1955. The earnings were equivalent to $4.57 a common share as against $3.85 in 1955.

Operating revenues were $262,791,000, a 12% increase over 1955, while operating expenses increased 13% to $238,584,000.

A comparative statement by National Airlines showed a net income for 1956 of $4,549,986, an increase of $1,218,262 over 1955. Operating revenues for the year amounted to $57,136,202, as compared with $51,265,126 for 1955. Expenses increased from $43,595,606 in 1955 to $48,172,046 last year.

Braniff Airways reported a net income of $1,885,799, an increase of 13%. Operating revenues were up 12.7%, while expenses went up 11.5%.

Trunk airlines that have asked the CAB for a 6% fare boost effective April 1 are Eastern, Braniff, Capital, Northwest, United and Trans World.

CAB Counsel Proposes Delta, Capital for Florida Route Awards

Washington—Delta and Capital Airlines were recommended last week for major route extensions that would provide additional service between Florida and the Great Lakes region without authorizing the entry of new carriers in the market. The recommendations were made by V. Rock Grundman, Civil Aeronautics Board bureau counsel in the Great Lakes-Southeast Service Case.

In a brief to CAB Examiner William F. Cusick, who will make formal recommendations in the case, Grundman said service to the areas under consideration is already highly competitive and that the addition of new competition should be avoided at this time. He said where additional competition is justified and required, it can be best provided by extending or modifying the authority of existing carriers.

Grundman proposed that Delta be placed in the Florida-Detroit market by extending its Miami-Cincinnati route to Detroit with the addition of intermediate points. This would place Delta in competition with Eastern Air Lines in the Detroit-Florida market as well as in the Florida-Chicago market, which both now serve.

Capital was proposed for entry in the Florida-Great Lakes market by extension of its Atlanta-Pittsburgh route to Buffalo via Youngstown, Akron-Canton, Cleveland and Erie, and from Atlanta to Miami via West Palm Beach and Tampa/St. Petersburg. In another case, a CAB bureau counsel has recommended that Capital be given a route between Philadelphia and/or Baltimore/Washington to San Juan (see page 41).

Consolidated in the proceedings were a wide variety of applications by Capital, Capitol Airways, Delta, Eastern, National, Northwest, Trans American, United and Trans World Airlines. A number of the applications asked for new service or removal of restrictions on existing service between Chicago and Washington. Other applicants wanted new or additional service between the Great Lakes and Florida and intermediate cities.

Grundman proposed that:

- **Eastern's Routes 5 and 6** should be consolidated into a new route from Miami to Chicago and from Miami to Detroit, serving intermediate points in Florida, Georgia, North and South Carolina, Virginia, West Virginia, Ohio and Indiana. Cincinnati and Fort Wayne, points not now included in Routes 5 and 6, would be served by Eastern on the consolidated route.
- **Delta's Route 54** should be extended from the present intermediate point at Cincinnati to Detroit via Dayton, Columbus and Toledo, by the addition of Louisville between Lexington and Cincinnati and by the addition of Orlando and Tampa/St. Petersburg between Jacksonville and Miami.
- **Capital's Route 51** should be temporarily modified and amended for five years by extending it beyond Pittsburgh to Buffalo, N. Y., via Youngstown, Akron-Canton and Cleveland, and Erie, Pa., and by extending it beyond Atlanta, to Miami via Tampa/St. Petersburg and West Palm Beach, subject to the restriction that no one-plane service shall be provided between points northeast of Charlotte, N. C., and points in Florida on Route 51.
- **Trans World Airlines'** Route 2 between Baltimore, Washington and Chicago should be modified by removal of existing longhaul restrictions. Restriction of services between Cincinnati and Indianapolis which prohibits nonstop service should be removed.
- **United's route between Chicago** and Washington and Baltimore should be modified by removal of existing longhaul restrictions and by the addition of Dayton and Columbus as intermediate points. The temporary authority heretofore granted to United to provide local service between Chicago and Pittsburgh should be made permanent.
- **Northwest Route 3,** Segment 2, should be amended by the addition of Baltimore as a co-terminal point with Washington and by the removal of the restriction that limits nonstop or turnaround service between Detroit and Washington/Baltimore via Pittsburgh and Cleveland.

Major Route Proposed For Trans Caribbean

Washington—Trans Caribbean Airways was recommended last week for scheduled operations between New York and Puerto Rico by a Civil Aeronautics Board Counsel. If the recommendation is approved, it will mark the first time an irregular carrier has been awarded a major long-haul passenger route in the scheduled field.

In a brief to Chief Examiner Francis W. Brown, Harry M. Shooman, counsel for the CAB's Bureau of Air Operations, said Trans Caribbean has operated between New York and San Juan on a non-scheduled basis since 1946 and is capable and ready to conduct scheduled operations as a third carrier. Eastern Air Lines and Pan American World Airways now operate between the two points.

One of the major reasons for recommending Trans Caribbean, Shooman said, was the airline's proposal to inaugurate a low-rate "skybus" fare of $45 between New York and San Juan. The sky bus service would be 102 seat configuration with no "frills." Trans Caribbean has been using Douglas DC-6 transports over the route.

In addition to placing a third carrier in the New York-San Juan market, the Bureau counsel also recommended improved service between Puerto Rico and the U.S. through the establishment of new gateways and the strengthening of present gateways.

Shooman proposed that Capital Airlines be granted a temporary certificate for five years authorizing the airline to operate between the co-terminals Philadelphia and, or, Baltimore-Washington and San Juan. This, along with the extension of one of Eastern's routes, would connect Puerto Rico with the Great Lakes region with a minimum loss of time or excess mileage.

For Eastern Air Lines, the Bureau counsel recommended that the airline's route between New York and San Juan be made permanent and that its certificate between Miami and San Juan should be extended to Chicago via Atlanta.

He also proposed that Riddle Airlines' all cargo certificate authorizing it to operate between New York and San Juan and Miami and San Juan be made permanent and that the airline be permitted to carry mail on a service rate basis.

The current proceeding was instigated by the CAB at the request of the Commonwealth of Puerto Rico, which filed a complaint that present air service to Puerto Rico is inadequate. One of the main points was the need for low cost service within reach of a majority of Puerto Rico's inhabitants.

Applicants to provide additional air service to Puerto Rico besides Trans Caribbean, Capital, Eastern and Riddle, include Delta, National, Pan American and U.S. Overseas.

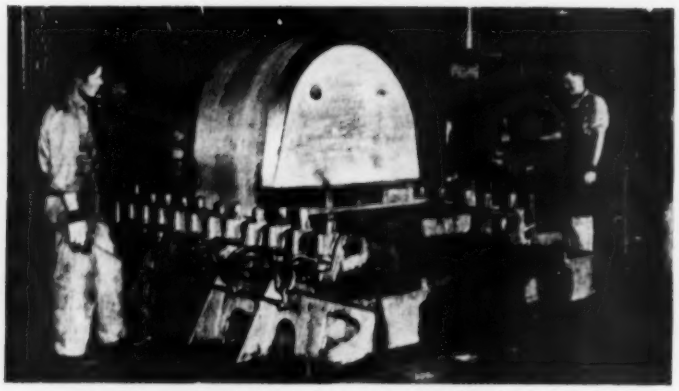
Air France Orders More Boeing 707s

Air France directors committee decided to order seven more Boeing intercontinental 707 jet transports, bringing total order to 17. Decision is being submitted to the government for approval but no trouble is expected.

Delivery of the seventeen Boeings will begin November 1959, and finish November 1960—two months earlier than limit set for 10 planes ordered in Dec. 1955.

Progress with **TITANIUM**

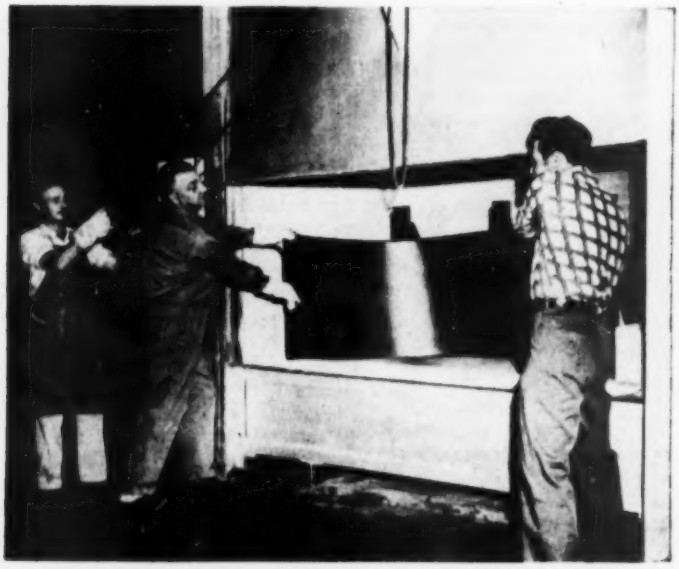
"In titanium stretch-forming, Mallory-Sharon material most consistent we have tried; simplifies fabrication"



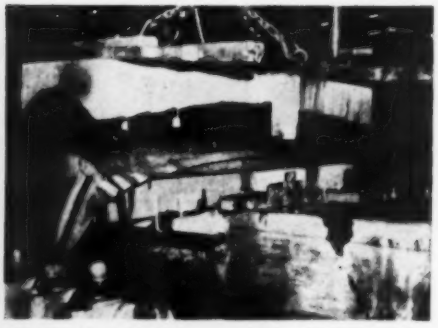
1. Initial forming *of titanium sheet at Hart Metal for jet engine pod. Since Mallory-Sharon titanium is certified in a definite strength range, springback is predictable, and allowed for in dies.*

. . . *reports Hart Metal Products*

● Because of titanium's springback characteristics, uniformity is particularly important in simplifying forming. Here, Mallory-Sharon sheet is preferred material for its consistent properties, the result of strict quality control. Each heat of Mallory-Sharon commercially pure titanium is certified for average strength and limits. For dependable quality, call us for your requirements, and for technical help in application.



2. Formed sheet *is annealed to relieve stress. With sheet material in a consistent strength range, Hart Metal reports that two or three stress relieving operations are eliminated.*



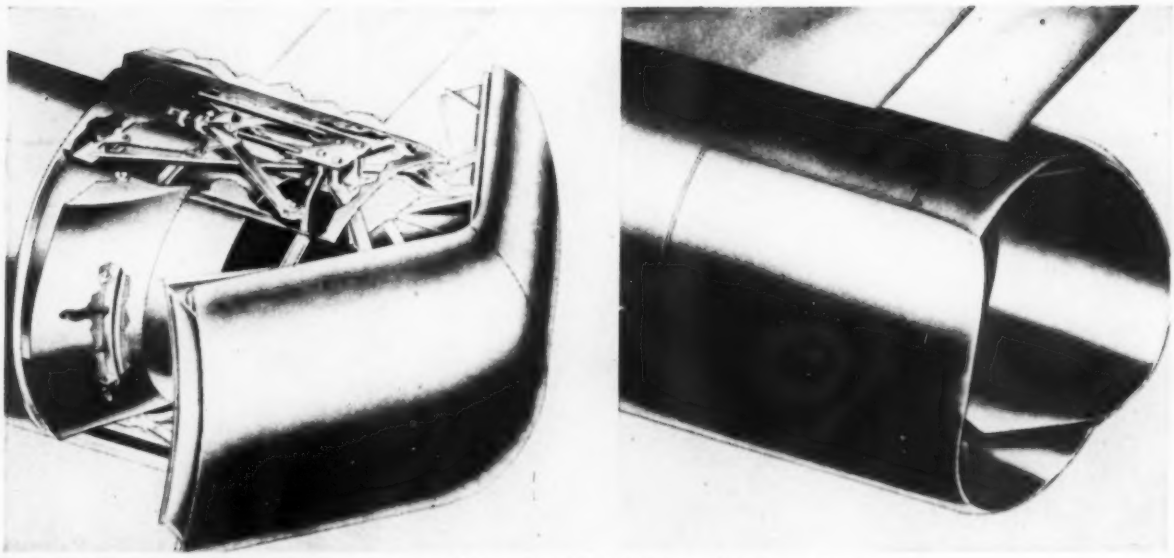
3. Double contour *produced by stretch-forming. Heated dies aid in obtaining desired shape with minimum number of operations.*

4. Formed skins are *checked in fixture and given final inspection. Fabricator reports very low scrap loss with uniform strength material.*

MALLORY Ti SHARON

MALLORY-SHARON TITANIUM CORPORATION · NILES, OHIO

Producers of titanium and titanium alloy sheet, strip, plate, rod, bar, billets



THRUST REVERSER is drawn in full reverse position (left), and (right) in full forward thrust position.

Thrust Reverser Spans Full Engine Range

New York—Fully modulated thrust reverser developed by Curtiss-Wright Corp. for commercial and military jet use can cut landing roll by as much as 50%, the manufacturer reports.

The externally mounted device can be precisely controlled to allow any per cent of thrust from full forward to full reverse, according to Curtiss-Wright. Full reverse position provides up to 60% of maximum forward thrust of the engine. Range of control allows precise performance during approach and flareout.

The reverser, manufactured by the company's Propeller Division, consists of two integral streamlined panels. It utilizes airframe structure such as aft pod, fuselage, or wing fairing to form the reverser. The device does not interfere with engine tailpipe or exhaust nozzle to increase drag, and it involves a minimum weight penalty, according to Curtiss-Wright.

Complete reverser system includes control systems and mechanical actuators designed for operation in the high temperatures of the aft engine sections.

Fail-safe feature of the reverser relies on aerodynamic forces. These prevent it from leaving its stowed flight position accidentally and return it to the stowed position when released from the reverser position. Actuating system also includes mechanical locks to fix the unit in full reverse position in the event of actuator power failure until it is released for full forward thrust.

Complete cycle from full forward to full reverse requires less than two seconds, the manufacturer says.

Company's Research Division developed the reverser, which has been ground tested but not yet flown in an airplane. Project now has moved to Propeller Division for production.

Curtiss-Wright's main sales targets are the Air Force, Boeing and Douglas. A company spokesman said airlines have shown interest in the reverser but that no firm orders have been made. Boeing and Douglas are working on their own reverser-suppressors and have no present plans to use C-W unit.

The device is compatible with a noise suppressor under development by Douglas, but not with Boeing's suppressor designs. Curtiss-Wright also is working on a noise suppressor for jets and the reverser would be compatible.

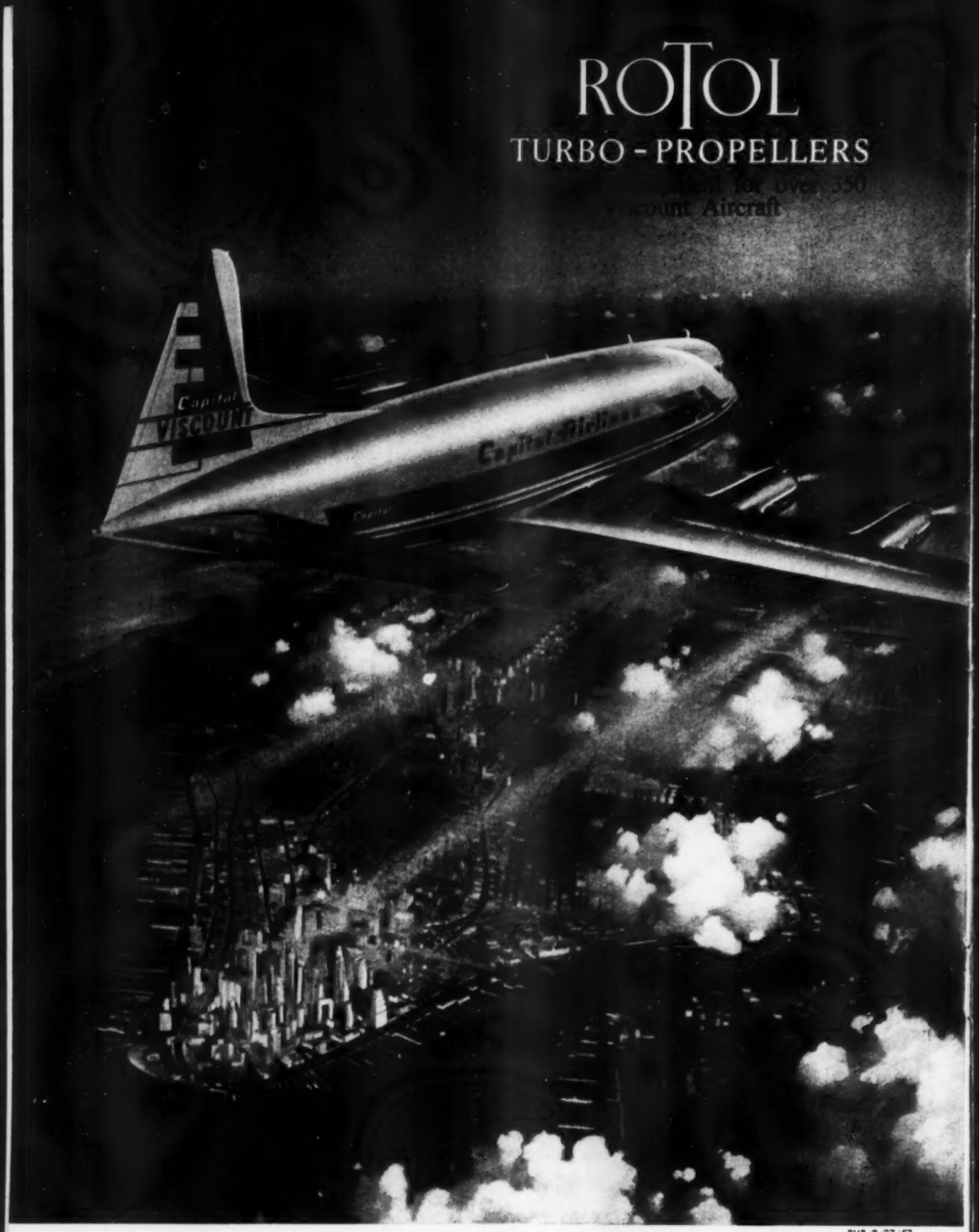
The Propeller Division has had considerable experience with throttlable controls through its X-2 rocket engine.

Other performance data reported by Curtiss-Wright from its test stand experiments:

- **No back pressuring** of engine.
- **No reattachment** of exhaust gases to fuselage.
- **No interference** with engine when reverser is in retracted position.
- **No adverse induced vibration.**
- **Stable operation** over operating range.

The company also says its reverser is designed for easy maintenance and overhaul.

CURTISS-WRIGHT jet thrust reverser is prepared for test on J65 at Quehanna, Pa.



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Electra Powerplant Testing Scheduled

Burbank, Calif.—Extensive development program is being pushed to roll up approximately half a million total engine hours on the powerplant for the Lockheed Electra turboprop before delivery of the first commercial model of the new airliner.

Conducted through the combined efforts of Lockheed Aircraft Corp. and General Motors' Allison Division, the program will involve both aircraft and test stands to amass operating time on the Electra power package—Allison Model 501 engine and Aeroproducts 606 four-blade hollow steel propeller.

At Lockheed, flight of the 501/606 combination will be conducted initially on a Super Constellation laboratory plane.

This will be augmented, in July, by airline-type endurance flying of four Electra power packages on another modified Super Constellation.

Beginning in January next year, engineering flight operations will begin with the Electra, and by middle of 1958, five of the planes will be in the program. Also, Lockheed's Georgia Division flight operations with production C-130As powered by Allison T56s, military counterparts of the 501, contribute to the program.

At Allison, test stand operation of numerous engines for endurance, compatibility and other information, is being conducted. In this operation, one Electra power package is "flying" simulated airline schedules.

It follows the airline pattern of start, taxi, takeoff, climbout, cruise, letdown, prop reversal and stop for 15 hr. every day.

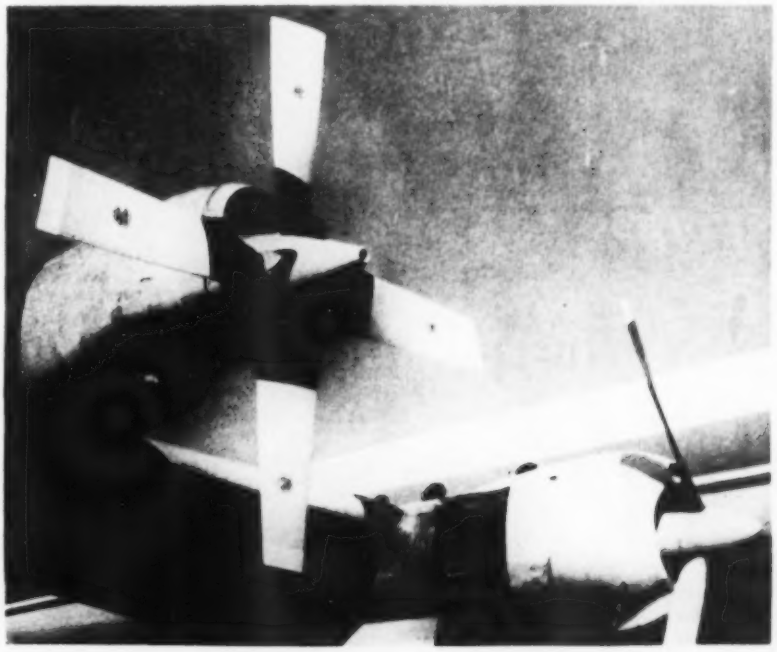
In-flight development of power packages is also in the Allison phase of the program, and by June, 1958, will include an Electra in the six planes involved in its flying laboratory fleet. Another facet at Allison is the Civil Aeronautics certification of the engine and propeller.

Nacelles of the Electra have the intake mounted on top to minimize possibility of ingestion of foreign objects from runways. Square-tip propeller is 13½ ft. in diameter, compared to 15 ft. on the piston engine Constellation test bed.

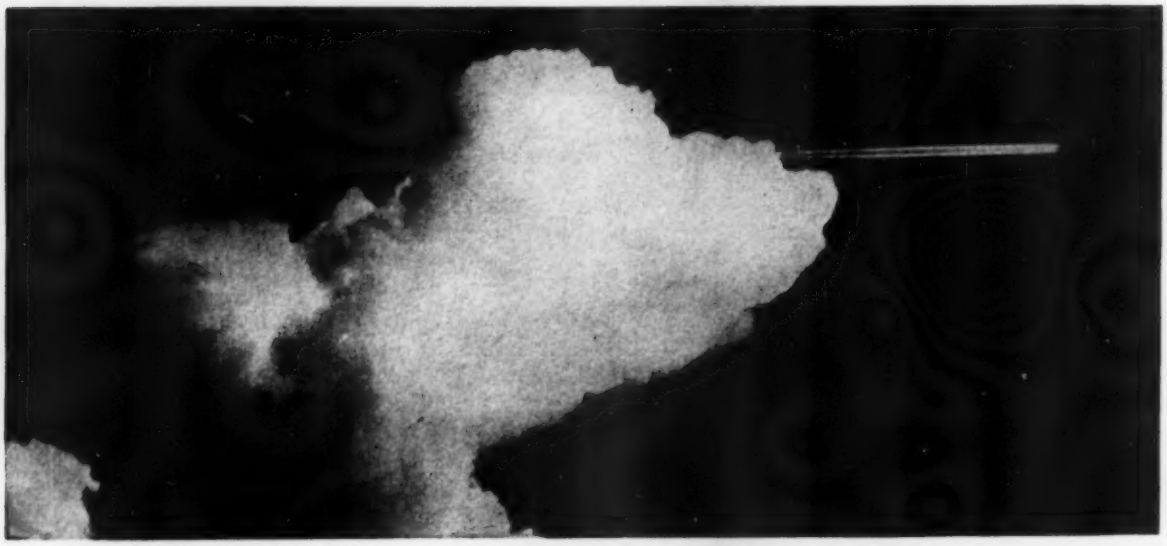
The design provides maximum amount of thrust with slow tip speed, the latter a goal in reducing cabin noise.

Allison also has the 501/606 combination mounted on its Convair Turbo-Liner test bed. Flight tests have begun at Indianapolis. Allison also has opened a 14,000 sq. ft. overhaul facility in Burbank across the street from Lockheed to handle minor overhaul of the engines and propellers.

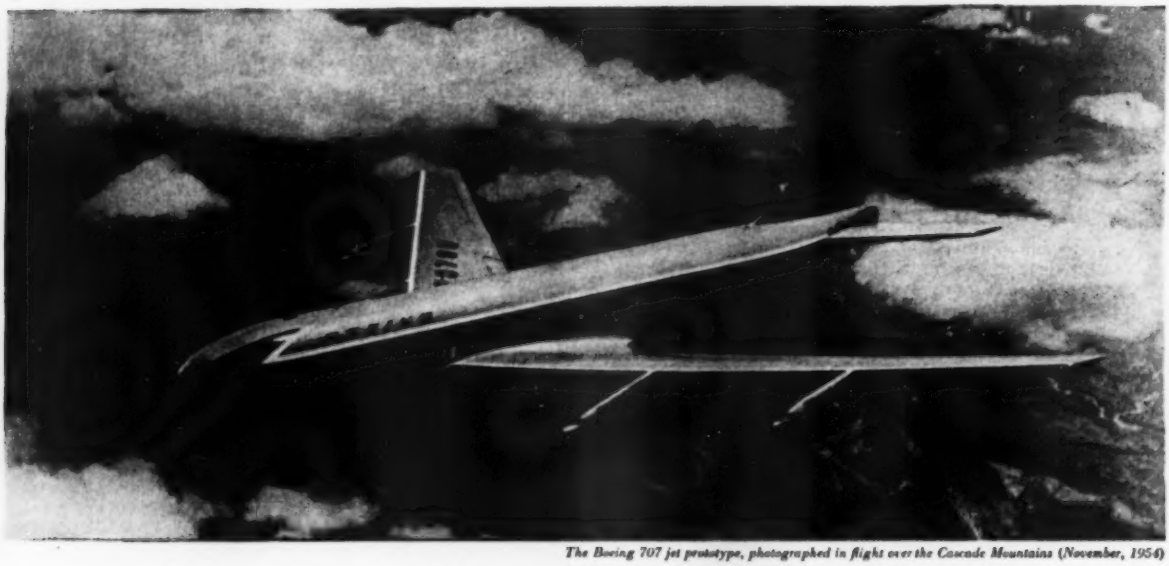
FIRST ALLISON 501D13 turboprop engine is lowered by crane for mounting on Super Constellation test bed. Lockheed and Rohr Aircraft employes handled the fitting of the first commercial model of the T56 engine on the same airplane that was used as an Electra test bed with the military powerplant. Completed installation with Aeroproducts 606 propeller is shown below. Intake on top is to guard against foreign object ingestion.



The world's most experienced builder



# of long-range jet aircraft brings you



The Boeing 707 jet prototype, photographed in flight over the Cascade Mountains (November, 1954)

the jet airliner of tomorrow...

There is only one American jet airliner now in the air—the Boeing 707. *It has been flying more than two years.*

In the superb 707 you will cruise smoothly six miles high, 600 miles an hour. Eleven famous airlines* have chosen Boeing jets . . . for many reasons, including this: when deliveries begin in less than two years, the 707 will be the most tested airliner ever to take to the skies.

Boeing leads in jetliners—because Boeing, back in 1952, had faith in the future of jet transportation, and began actual construction of America's first jet transport.

BOEING 707

*AIR FRANCE • AIR INDIA • AMERICAN • B.O.A.C. • BRANIFF • CONTINENTAL • LUFTHANSA • PAN AMERICAN • QANTAS • SABENA • TWA

SHORTLINES

▶ **Swissair's 1956 gross revenue** increased 17% to $35,091,740, and the airline's load factor was 66.5% compared to 64.8% in 1955. Passengers totaled 773,956 in 1956, an increase of 23%. Freight was up 23% to 10,000 tons, mail totaled 3,608 tons, a 9% increase.

▶ **Emery Air Freight Corp.** has opened a new office at Akron-Canton Airport. Facility is 35th office in the freight forwarder's system.

▶ **Lufthansa German Airlines** plans daily New York-Vienna service beginning April 27. New Convair 440s will connect at Frankfurt with the carrier's transatlantic Super G Constellation flights. Flight time Frankfurt-Vienna will be 2½ hours.

▶ **Four "terminal city"** contracts totaling $1,122,000 were awarded last month by Port of New York Authority for work at Idlewild. Contracts cover installation of 41 mercury vapor light towers for illumination of terminal area, expansion of central heating and refrigeration system, directional signs, parking toll booths.

▶ **Slick Airways** transported champion steer to and from Florida cattle exhibition. Steer comprised the entire C-46 payload.

▶ **Lockheed Aircraft Service**-International delivered 2,703 aircraft last year. Four-engine commercial planes accounted for most of the work, with line maintenance the biggest item, according to the Idlewild maintenance base operator.

▶ **Cia. de Aviacion Faucett S.A.** (Peru) has bought a DC-4 from Panagra. Reported price was $550,000.

▶ **West German-Spanish** bilateral air agreement grants Lufthansa rights to direct routes between German airports and Madrid, Barcelona and Palma de Mallorca, instead of only to Madrid. In return, Iberia gets Frankfurt and Stuttgart. For transit traffic, Lufthansa may stop over in Madrid en route to Latin America, while Iberia may use Hamburg and Munich as intermediate stops.

▶ **Trans Canada Airlines** is shipping 1,000 plastic signs to travel agents in North America and Europe. Agents can make up own messages for insertion in 11 by 18 in., flashing-lighted displays.

AIRLINE OBSERVER

▶ U.S. airlines have been rebuffed by Great Britain for the fourth time in a year in the latest U.S. move to obtain new operating concessions from England on international routes. Specifically, after years of conferences, Britain still refuses to close the gap between Frankfurt and Zurich on TWA's route through London to the Far East. All present TWA London flights terminate at Frankfurt, and Far East flights must be routed from New York or Shannon through Paris, Zurich or Geneva. Latest discussion of the issue came during the recent review of the Bermuda bi-lateral treaty. The treaty was "reaffirmed" by the delegates. However, one observer said, "nothing was accomplished at the conference since Britain is asking for nothing and is giving nothing."

▶ **Trunklines are not likely to follow Bonanza Air Lines plan for granting reduced fares to the clergy. Bonanza's fares, which allow a 50% reduction on space-available tickets sold to "ministers of religion," went into effect last month following approval by the Civil Aeronautics Board. Most airline tariff officials feel the "space available" provision will cause some misunderstanding and believe the term "ministers of religion" is too encompassing to restrict the privilege to bona fide clergy.**

▶ American Airlines will train 746 stewardesses this year to increase its stewardess complement from 1,242 to 1,360 by the end of the year. Pilot roster will be increased from 1,565 to 1,696, and the flight engineer complement from 499 to 575.

▶ **Erco Division of ACF Industries estimates pilot training costs for multi-engine aircraft at $63 per hour if simulators are used as compared with $550 for actual aircraft training.**

▶ United Aircraft Corp. spent more than $1.7 million as a customer of the scheduled airlines in 1956. Company representatives traveled over 17 million passenger-miles during the year, and 3.7 million pounds of material were shipped by air parcel post, air freight and air express.

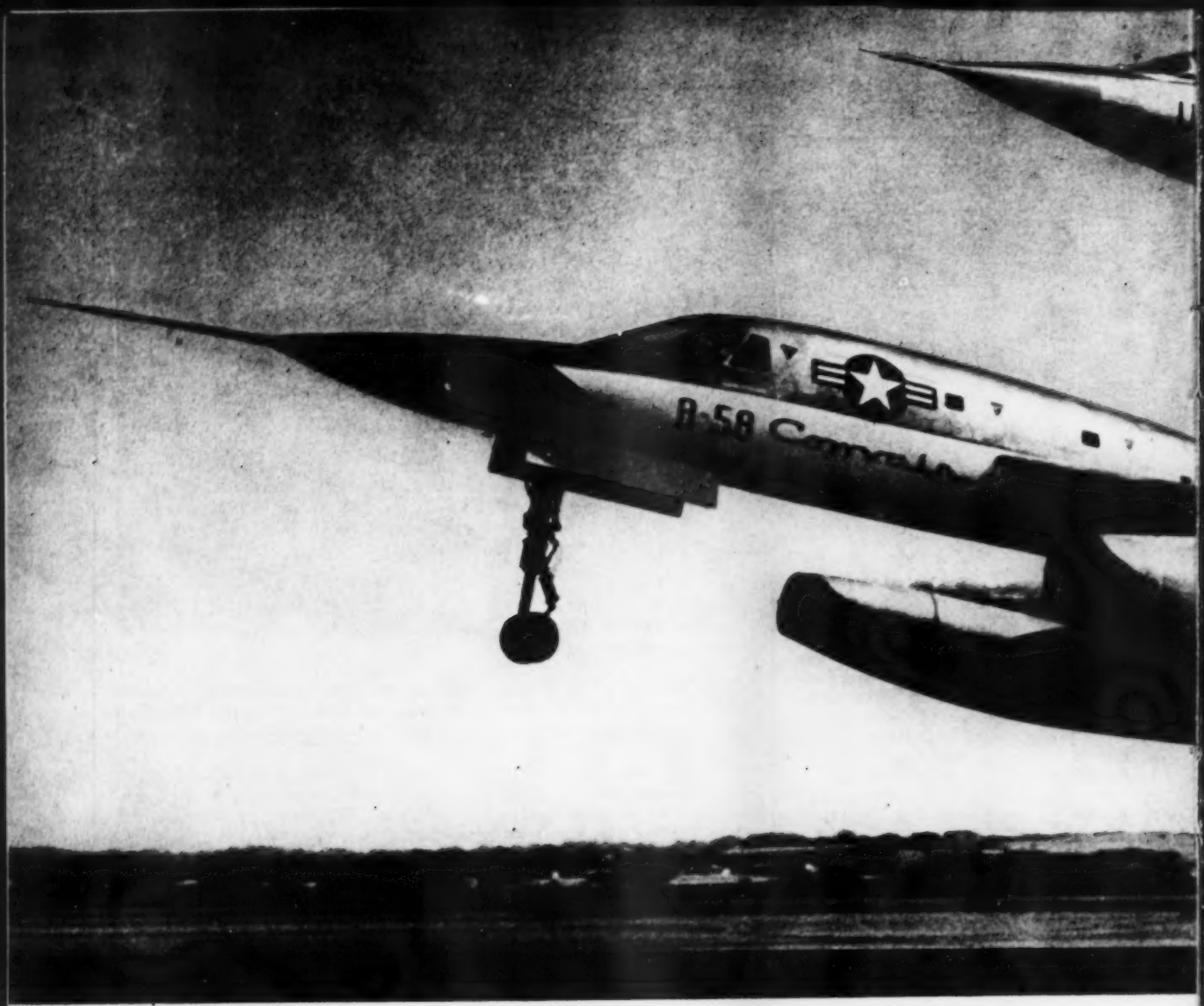
▶ **First Bristol Britannia built at Short Brothers and Harland plant at Belfast is scheduled to make its maiden flight this month. Short is building 25 Britannias.**

▶ Watch for new efforts by U.S. and Britain to bring airworthiness requirements and regulations of the two countries more closely into line. Each country now accepts airworthiness certificates of the other but maintains the right to require "special conditions" and modifications of aircraft approved. At present, British Air Registration Board officials are in America checking the Boeing 707 while six technicians from the Civil Aeronautics Administration are in England examining the Viscount 800, Britannia 300 and Comet 4A.

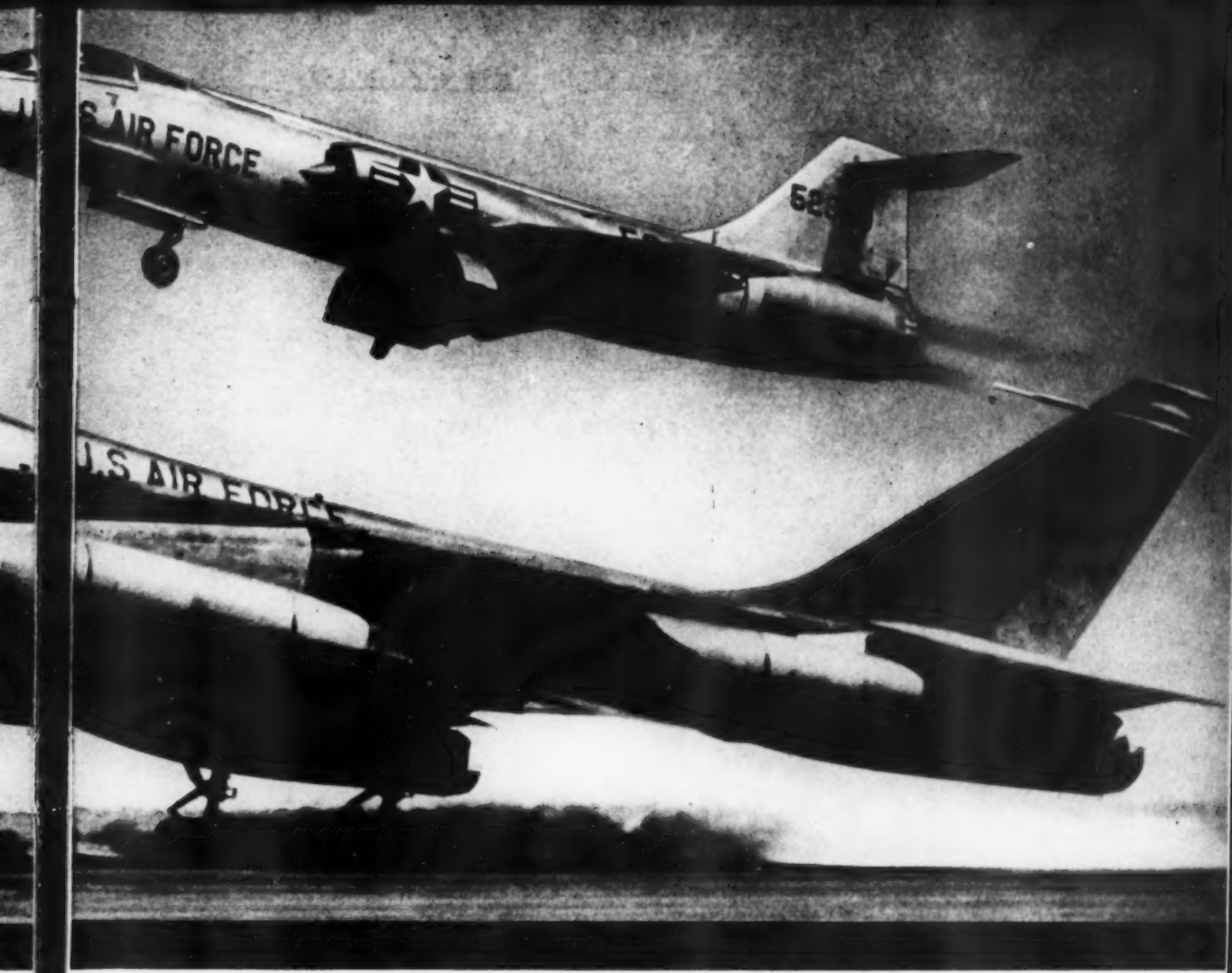
▶ **Northwest Airlines has increased overhaul time on its Curtiss-Wright R3350 Turbo Compound engines from 1,200 to 1,300 hr. Overhaul period for R2800 and R2000 engines is 1,700 hr.**

▶ Soviet airline service is not without its deficiencies, according to one traveller whose complaints against Aeroflot were printed in the Soviet newspaper Trud. On a recent trip, the passenger learned he could not purchase a through ticket to his destination but had to stop en route and buy a second ticket to complete his itinerary. At the airport of the stopping point, he was told by the agent that "for the convenience of the passengers, tickets are sold only at the city ticket office." This called for a roundtrip from the airport to the center of town before he could continue.

▶ **Canadian Pacific Airlines will renew attempts to obtain Canadian government approval for conversion of four C-46s to a combined passenger-cargo configuration. The government refused to grant such permission several years ago.**



HOW GENERAL ELECTRIC J79 TURBOJET PAYS OFF IN SPEED



The fastest bomber and production fighter in the world (above) offer striking evidence of the performance and versatility of General Electric's J79 turbojet.

The ideal supersonic powerplant, the J79 brings extremely high altitude capability to USAF's Lockheed F-104A and Convair B-58, plus:

- **High thrust for fast take-off, climbs, supersonic capability.** The J79 delivers more thrust per pound than any U. S. turbojet of comparable size.
- **Low engine weight for light airframes.** Compact in design, the J79 is smaller and lighter than its famous G-E predecessor, the J47 turbojet.
- **Small frontal area for "clean" airframes, reduced drag.** The J79's minimum engine envelope contributes to low drag characteristics of airframes whether engine is mounted in fuselage or nacelles.

Today, the G-E J79's high power, light weight and small size are paying tremendous dividends—in speed—to American airpower. *General Electric Company, Cincinnati 15, Ohio.* 235-18

NEW 609-MPH CONVAIR JETLINER will be powered by G-E CJ-805 turbojet, ideal powerplant for medium-range operation. Above, G.E.'s Neil Burgess and Gerhard Neumann discuss model.

Progress Is Our Most Important Product

GENERAL ELECTRIC

HOW GENERAL ELECTRIC J79 TURBOJET PAYS OFF IN SPEED

FACTS

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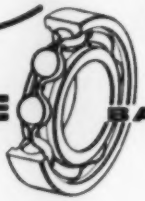
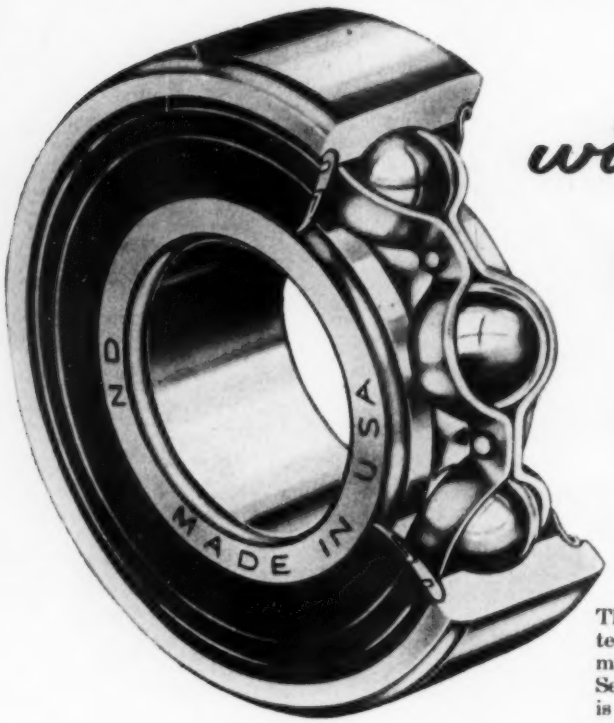
NEW DEPARTURE  **BALL BEARINGS**



with

SENTRI-SEAL

on guard against dirt and wear!

The unique design of the Sentri-Seal gives optimum protection against dirt, and includes a number of other major advantages.

Sentri-Seals can be removed, easily replaced. As the seal is of synthetic rubber in which two metal rings are embedded, a constant-rate spring is created between the

The fastest bomber and production fighter in the world (above) offer striking evidence of the performance and versatility of General Electric's J79 turbojet.

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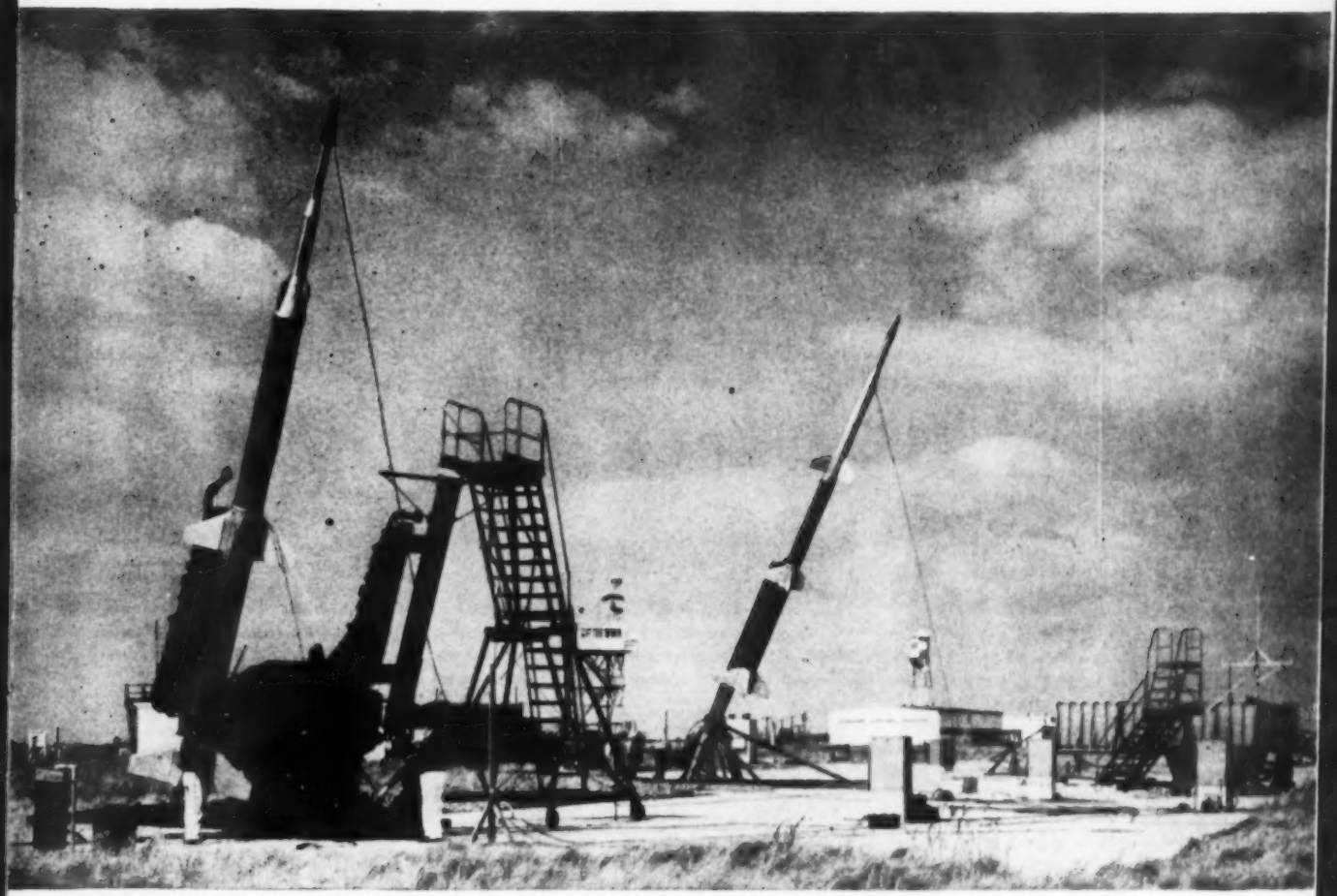

TWO NACA four-stage test vehicles for research above Mach 7 are mounted on launchers at Pilotless Aircraft Research Station.

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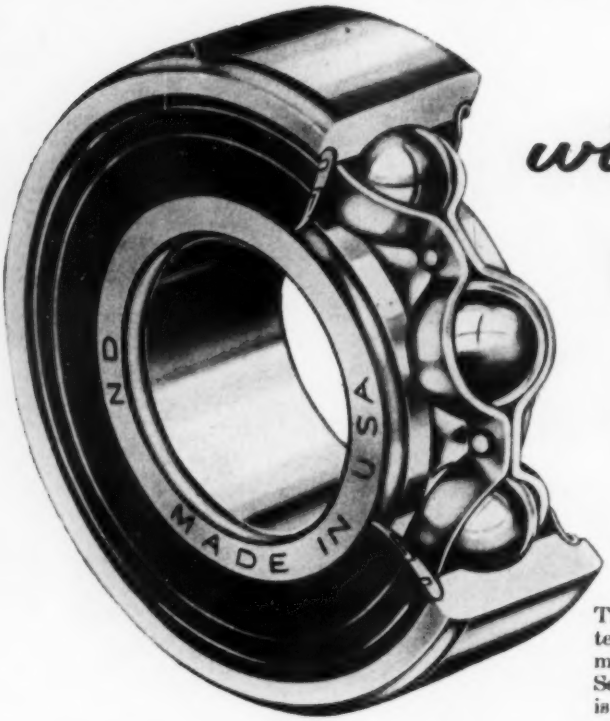
NEW DEPARTURE BALL BEARINGS



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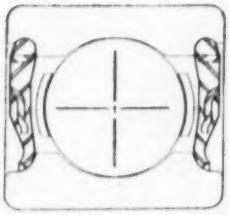
SENTRI-SEAL

on guard against dirt and wear!

The unique design of the Sentri-Seal gives optimum protection against dirt, and includes a number of other major advantages.

Sentri-Seals can be removed, easily replaced. As the seal is of synthetic rubber in which two metal rings are embedded, a constant-rate spring is created between the rings. Inherent flexibility prevents distortion of the bearing outer ring due to seal insertion, permitting the use of bearings to the higher accuracy specifications. The spring action maintains an efficient sealing contact with the bearing ring to bar dirt and retain lubricant. Sentri-Seals are relatively inert to oils and greases and operate satisfactorily through a temperature range of −40°F. to 225°F. Specifications available for still higher temperatures. In applications where relubrication is desired, it is easily accomplished by the injection method.



The diagram shows in section the New Departure Sentri-Seal. Lip-contacting surfaces are form-ground simultaneously with the ball race, giving an extremely high degree of concentricity between sealing surfaces and the raceway.

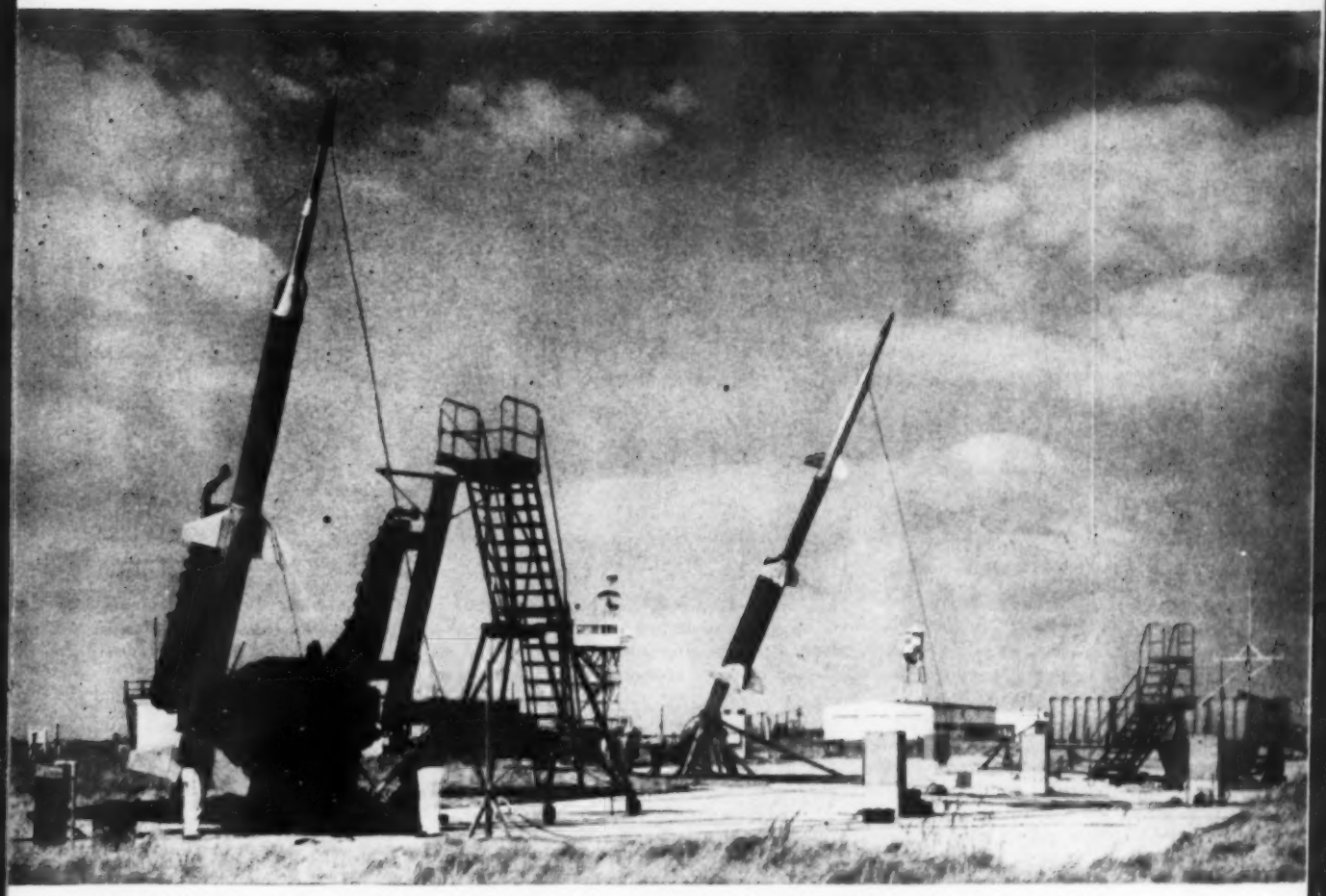
SEE "WIDE WIDE WORLD" SUNDAYS—NBC-TV

Sentri-Seal is available for a range of sizes in single-row, standard-width bearings and also in two types of New Departure adapter bearings. Sizes, dimensions and capacities are listed in the latest New Departure catalog.

Write for full details on Sentri-Seal

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.



TWO NACA four-stage test vehicles for research above Mach 7 are mounted on launchers at Pilotless Aircraft Research Station.

ICBM Tests Gain Hypersonic Glider Data

By Evert Clark

Wallops Island, Va.—Aerodynamic and structural answers leading to the development of hypersonic manned glide rockets are being sought with new types of rocket-powered test vehicles at the National Advisory Committee for Aeronautics' Pilotless Aircraft Research Station here.

Research on what NACA calls "winged boost glide aircraft" already is beginning to yield the basis for an engineering approach to these man-carrying rockets.

Wallops Island is an outpost of the Pilotless Aircraft Research Division at NACA's Langley Aeronautical Laboratory 70 miles away and is one of the few outside-the-laboratory facilities now available for the study of hypersonic flight.

A four-stage test vehicle fired from Wallops Island in October, 1954, reached a speed of Mach 10.4 and an altitude of one million feet. "Somewhat higher speeds" have been reached since that time, according to NACA Chairman Dr. James H. Doolittle.

Stable Flight at Mach 5

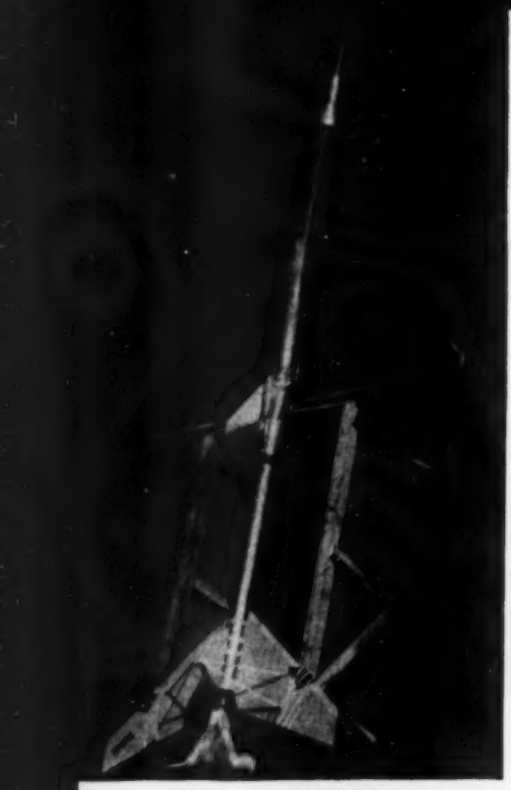
Emphasis now is on the problems common to intercontinental ballistic missiles and the hypersonic bombers that will follow them—materials, structures, designs and controls that will produce stable flight in speed ranges above Mach 5.

Missiles are the more immediate problem. But NACA says that winged boost glide rockets—gaining part of their lift from centrifugal force and traveling at Mach numbers up to 18 and altitudes above 300,000 ft.—appear to be one of the most effective possibilities for future man-carrying vehicles.

The potential of this type of aircraft, NACA says, is practically unlimited. Difficulties would seem to be almost unlimited, too—but finding the answers to existing and future missile problems will provide many of the answers necessary for hypersonic aircraft flight.

Some design characteristics of a hypersonic glider might be:

- **High fineness ratio nose cone** as opposed to the blunted missile nose cone needed for rapid, almost vertical, reentry into the dense lower atmosphere.
- **Variable geometry lifting surfaces** since the very thin, low aspect ratio wings desirable for high speed flight will not produce the high lift necessary for landing.
- **Extreme leading edge sweep** to wings.



DELTA wing model (left) was one of series used in supersonic flight tests. Booster propelled it to high subsonic speeds and then rocket in model took over. Model for Mach 5 performance tests (center) has high fineness ratio nose cone similar to those planned for hypersonic glider. Fillets on model (right) showed they can be added without increasing drag and led to use of smaller fillets on Snark.

Reduction of leading edge heating by increasing sweep has been studied intensively by NACA. A 60 deg. delta, for example, will produce approximately half the heat input of a straight wing. With the reduction of drag and laminar flow heating, however, comes an increase in turbulence.

• **Reaction type controls.** At the extreme altitudes and speeds that a hypersonic glider will encounter, the effect of conventional control surfaces would be intolerably low because of the thinness of the air and the very high inertia of the aircraft. Uncontrollable oscillations, already experienced in research aircraft and some high performance military aircraft probably would be avoided or overcome by use of pulsejets or pulse-rockets at wingtips and tail.

High Temperature Survival

Flight at the speeds conceived for hypersonic gliders also will require cooling beyond that necessary to maintain structural integrity of the aircraft. Cooling to protect the pilot, his electronic gear, his weapons and his fuel is being studied.

Joseph A. Shortal, chief of the Pilotless Aircraft Research Division (PARD), described survival in high temperatures as "a whole open field," and said a great deal of new effort is being put into collecting the data that will close some of the gaps.

Shortal's division has been working with heating at speeds above Mach 4 for at least four years. In 1952, a two-year program aimed at reaching Mach 10 by October, 1954, was begun. In that target month, a four-stage vehicle composed of two Nike boosters and two special stages powered by Thiokol T-40 and T-55 motors reached Mach 10.4. Subsequent firings have included four-stage vehicles boosted in the first stage by the Honest John rocket.

Ready for Future

Shortal describes the hypersonic glider as "just an aircraft of the future" and says that NACA's interest in it is simply a continuation of what the committee is always doing—attempting to "stay in front, speed-wise and design-wise, in case it should be called for."

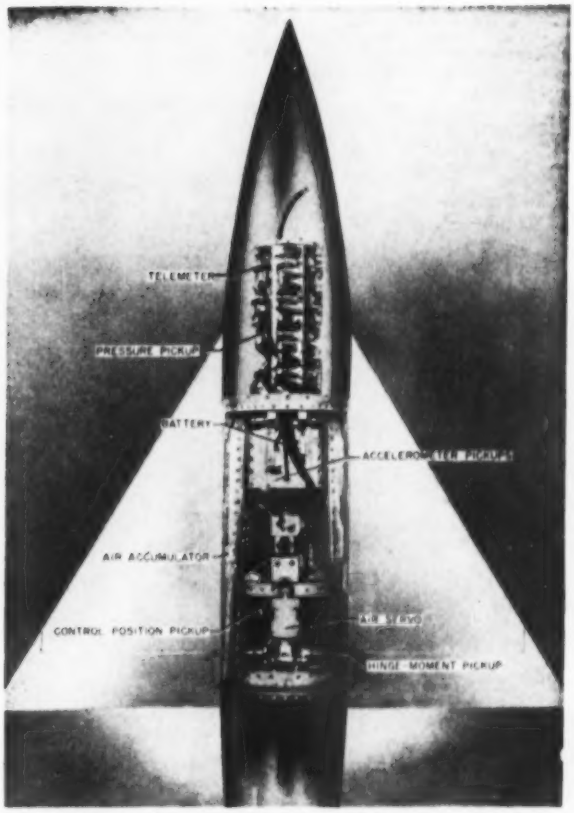
The primary areas of research at Wallops now are:

• **Aerodynamic heating.** Importance of this was recognized from the beginning of Wallops' operation. Early work was done chiefly to confirm heat transfer theories originally worked out with boiler pipes. First test vehicle was the RM-10, a low-drag, high fineness ratio parabolic body of magnesium fired with a booster. First firing was in 1946, and this type vehicle remained satisfactory for heating explorations up to Mach 4 before NACA had to switch to Inconel. The RM-10 reached Mach 4 and 100,000 ft. five years ago. Later shapes have been of two types—high-fineness ratio cones applicable to long-range aircraft such as the hypersonic glider, which will have to withstand high heating over long periods, and blunt noses to withstand even higher heat inputs for short times. Heating affects the whole range of Wallops' research. Materials must be found that will not burn up, and will provide sufficient structural integrity to permit studies of drag, interference, aeroelasticity, stability and control.

• **Automatic control.** General research in this field has been going on since Wallops was created. Emphasis now is on guided missiles—stabilization, and the control of them. A limited amount of study is going on now, mostly on air-to-air missiles. NACA does not develop complete guided missiles, but it has contributed design data to a number of them. In recent years, it has concentrated upon simplification of control. One approach is constant torque for control surfaces—an attempt to eliminate the gain changing device that senses density and varies deflection. Instead of calling for a certain deflection, a torque servo would call for a certain torque. Deflection would then vary with speed and altitude. Theoretical studies and some actual experimental studies have been conducted.

• **Flutter.** Free-flight launchings were once the sole source of data on flutter

TWIN engine 6.6 in. ramjet test vehicle boosted by two Deacon rockets reached 67,000 ft. altitude, speed of Mach 3. Booster pushes vehicle to Mach 1.7.



CUTAWAY drawing shows typical layout for instrumentation of free-flight, rocket launched research model used at Wallops Island. Telemeter is mounted in nose.

FLIGHT behavior of Douglas XF4D-1 and drag effect of external stores was obtained by firing this one-tenth scale model at Wallops Island. Booster rocket motor propelled model to supersonic speeds. After it fell away, model coasted in free flight through transonic speed range. Instrumentation in model transmitted data to NACA scientists for analysis.

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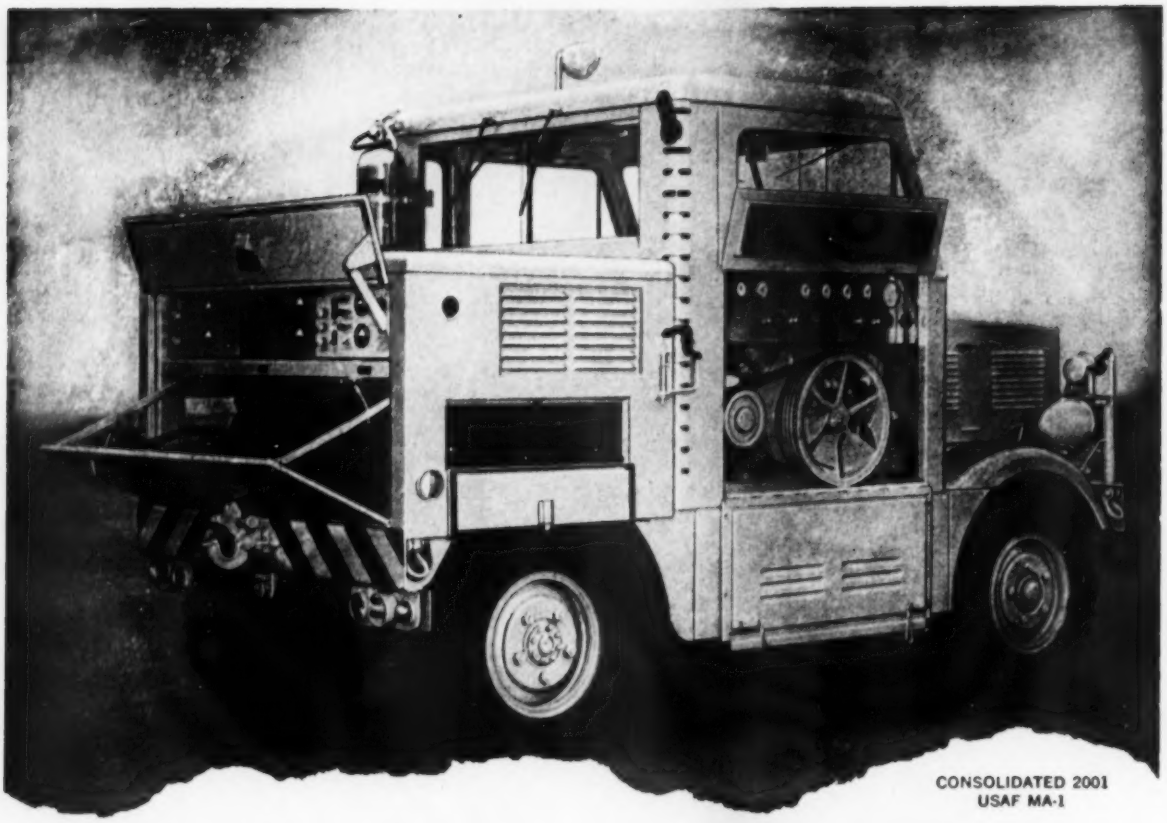

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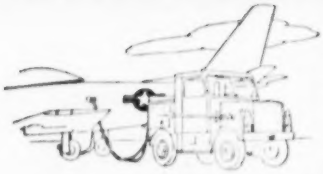
GROUND SUPPORT !



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TESTS of jet vanes immersed in exhaust of solid propellant rocket booster for stability enabled NACA to reduce booster fin area.

through the transonic range. Now tunnels can accomplish much of the necessary research, but Wallops may increase its activity again as the heating problem grows. Temperature by itself can cause changes in wing stiffness, resulting in violent flutter.

• **Dynamic stability.** The percentage of effort in this area remains fairly constant with perhaps a dozen models a year being launched. They are complex and the data reduction is complex. Wallops' researchers have found a high correlation between test data and actual flight results since the rocket-launched model is entirely free and gives all true effects. Test models have included the F-101, F-104 and the Falcon missile. Pulse rockets mounted at right angles to the line of flight are used to disturb the model, with lift, drag and stability data being determined from the resulting oscillations.

• **Drag.** Drag is measured in every flight, regardless of the main purpose of the test. For simpler models, Doppler measurements are sufficient, but more complicated ones require telemetering. Studies have included wing-body interference, addition of wing fillets, drag of external stores at supersonic speeds, etc.

• **Control effectiveness.** Models can be flown with fixed-control deflection, and the rate of spin can be measured by means of a polarized ratio signal transmitted from a spinsonde unit in the nose to a ground antenna that is polarized the opposite way. Effectiveness of both aerodynamic and jet vane controls have been studied.

• **Ramjets.** This is done intermittently in conjunction with NACA's Lewis Flight Propulsion Laboratory at Cleveland. Past work has included a 1950 flight to 67,000 ft. at Mach 3 with a twin-engine, 6.6 in. diameter ramjet boosted to approximately Mach 1.7 by two Deacon rockets. Main study was on combustion and engine performance at high speeds and altitudes. Largest ramjet engine launched at Wallops was 10 in. diameter, large enough for an interceptor missile. The 6.6 in. ramjets, weighing 35 lb. each, delivered about 5,000 hp. each at Mach 3. A blowdown supersonic tunnel at Wallops is used to measure starting characteristics and reliability of the control system and for calibrating fuel flow at one speed.

• **Jet effects and inlets.** This includes the study of the flow from a jet engine and its effects on trim and lift of tail control surfaces, and research into pressure recovery, drag loss, etc., of the flow into engine inlets. Like most of the Wallops' work, it is supplemented by and coordinated with wind tunnel and actual flight data.

Pre-Flight Facility

In addition to rocket-powered models, researchers at Wallops use a pre-flight jet facility that includes a 12-in. circular ethylene jet producing temperatures of 3,000-3,500F a blowdown tunnel with a 27 x 27 in. nozzle with a range of from Mach 1.4 to 2.25, with true sea

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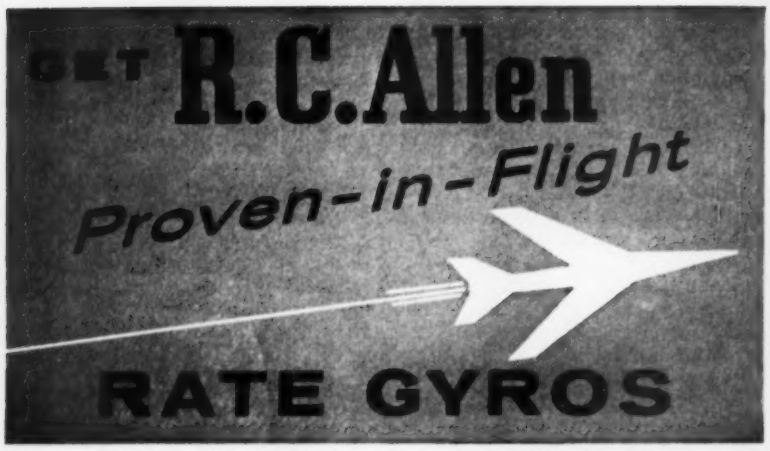

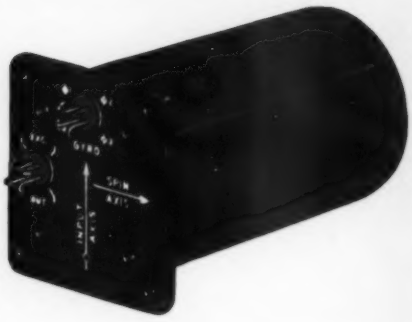

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level density and temperature at all numbers and a 5-8 sec. running time at Mach 2.25; a 12 x 12 in. nozzle with a 60 sec. run at Mach 1.4; and a 8-in. circular jet.

This facility gives sea level ambient temperature even after expansion through the supersonic nozzle. It is used for studying stagnation temperatures, heating, structures, ramjets and bomb release on all series of bombs.

Even though almost every firing at Wallops is the equivalent of a prototype, the average of successful firings runs about 80%. Of the 3,000-odd firings since 1945, the average per year now is about 200. It once was as high as 400 before the models and their instrumentation became so complex.

Wallops' History

It was the effort to stay out in front in transonic and supersonic flight 12 years ago that led to creation of the launching site at Wallops, a narrow, isolated strip of Atlantic Ocean beach in the extreme northeast corner of Virginia.

As early as 1943 NACA instrument specialists had developed telemetering techniques and equipment to return data on wing shapes and body pressures.

Free-flight models were dropped from an F-82 Twin Mustang, a B-17 and a B-20. But even with the heaviest bomb-drop models released from as high as 43,000 ft. speeds above about Mach 1.3 could not be reached.

The Wallops station was established to obtain actual experimental data with an instrumented air-to-air missile shape proposed at Langley, but the second project—measurement of drag on simple aircraft models launched with rocket boosters—soon became an important part of the work.

The original collection of tar paper shacks has given way to a handful of permanent buildings since 1945, but a modified SCR-584 tracking radar still is the workhorse of Wallops' instrumentation.

Model Launchings

More than 3,000 rocket-boosted or rocket-powered test models have been launched from Wallops in contrast to the 15 or 20 free-flight drops accomplished through the slow, cumbersome process of flying a bomber to altitude before the first rocket model was fired.

More than 1,000 of these have been simple shapes with no instrumentation. Drag was measured and calculated with the help of a radio sonde, the SCR-584 radar and a Doppler velocimeter. A basic understanding of drag problems in the transonic range was being gathered well before the Bell X-1 reached Mach 1 in 1947.

The third series of models flown provided airplane control data that was not

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HOW WEATHER CONDITIONS AFFECT THE PROPAGATION OF RADIO WAVES

RADIO RECEPTION may vary from poor to exceptional, depending on the temperature stratification. Temperature inversions alter refraction characteristics of the atmosphere. This can result in freak reception over great distances on VHF channels.

Precipitation static—ice crystals, snow flakes and rain droplets striking aircraft can cause crackling in headphones.

Static due to lightning discharges. These occasional bursts and crashes can be picked up at considerable distance. It is often your first indication of thunderstorm activity.

How to minimize static: Change altitude if it can be done safely. Decrease speed in rain or snow storms. Where possible, avoid dry snow and cirrus clouds composed of ice crystals. Keep radio volume turned low to reduce background noise. It is preferable to use a higher frequency broadcast station for ADF homing instead of low frequency range station. During periods of static, push headphones over temples when not listening—to keep fatigue to minimum.

Aurora Borealis, associated with magnetic storms. These extra-terrestrial phenomena cause communication fadeouts. Tune in to Time Signal Broadcasts of National Bureau of Standards (5 or 10,000 kilocycles for forecasts of periods of poor reception).

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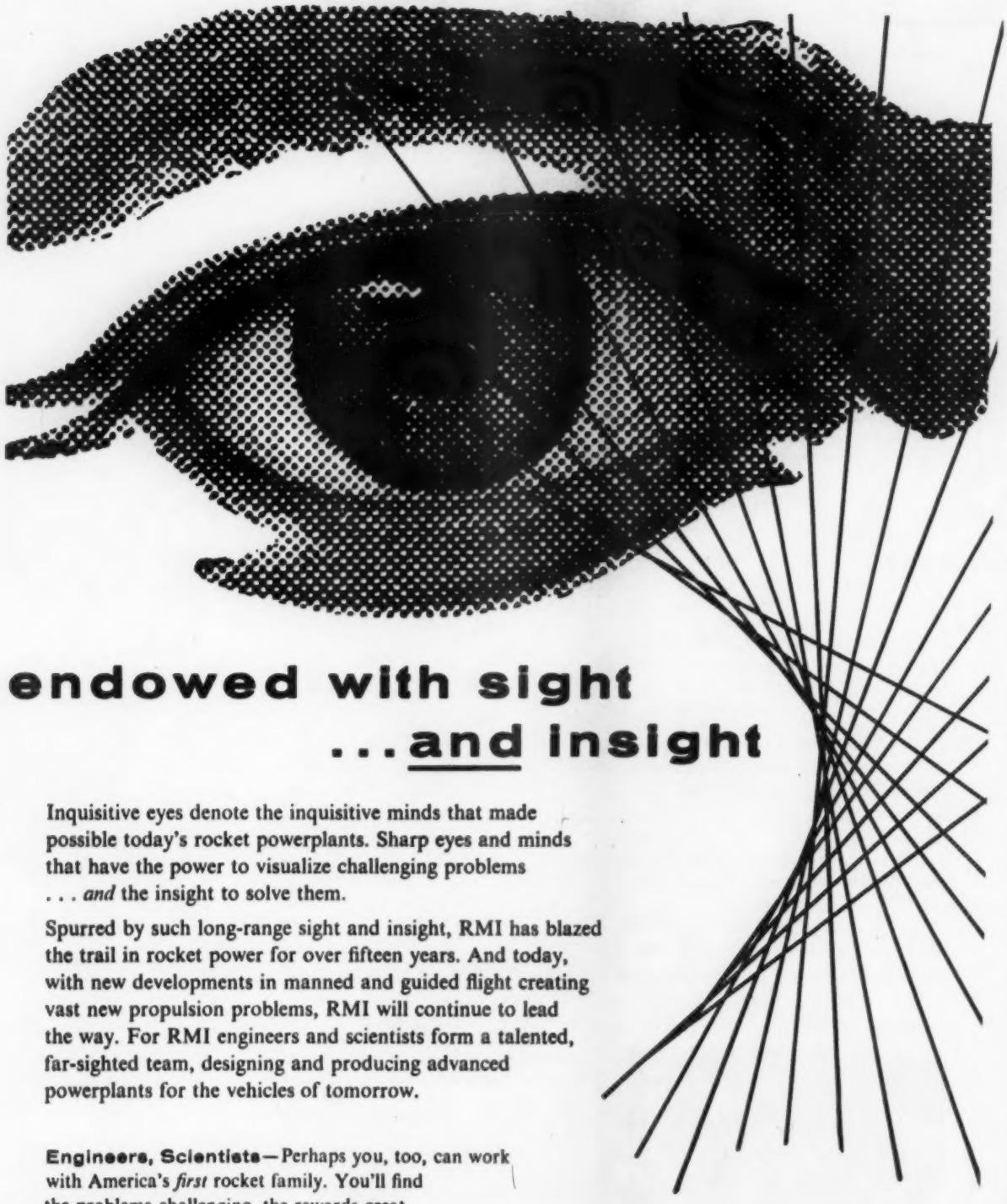

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available from any other source for quite some time. Out of this work came the knowledge that high slope trailing edges of ailerons cause flow separation and reversal of controls in the transonic range. This led to the quick fix of blunt aileron trailing edges for the X-2 research plane. It also produced a better understanding of the need for thin wings to eliminate reversal, drag and aileron buzz.

Most control research in the hypersonic range will be done in tunnels, but Wallops has one control study at Mach 6 in progress. Although hypersonic aircraft are the next step, Wallops still studies drag and control problems in the transonic range.

Wallops' Work Force

Wallops' work force consists of 80 men, most of them natives of Virginia who live on the Eastern Shore and commute to Wallops by ferry. Half a dozen are engineers and the rest technicians. Work at Wallops is directed from Langley by Robert Krieger. John C. Palmer heads the research section on the island proper.

The Pilotless Aircraft Research Division employs another 80 research engineers, plus supporting personnel, at Langley. Operationally, Wallops is under PARD, but the Wallops budget is separate, giving Congress a direct look at what is spent on NACA's research rocket launching.

Three-fourths of the research problems that PARD deals with originate there in the pursuit of advance knowledge of speeds, materials, etc. Right now, about 15% of the work is related to some specific airplane. This means speeds are less than Mach 3 since these aircraft were designed years ago.

Wallops' Contribution

The scope of Wallops' contribution to modern military missiles and aircraft is evident from the list of models currently or recently used in research investigations—North American's Navaho, the Northrop Snark, the Bell Rascal, the Sperry Sparrow, the Hughes Falcon and the Navy's Sidewinder, the Chance Vought F8U Crusader, Grumman F11F Tiger, Douglas F5D Skylancer, McDonnell F-101 Voodoo, Convair F-102, Republic F-103 and F-105, Lockheed F-104 and North American F-107.

Intricate instrumentation for free-flight aircraft and missile models is done by Langley's Instrument Research Division. An example of the kind of problem this division is sometimes handed is the switch from bomb-drop models to rocket-fired models.

Instrumentation for the rocket-launched models had to be contained in approximately one-eighth the volume it occupied in the bomb shapes, even

ROCKET POWER PROGRESS REPORT

Atomic Radiation for Rocket Testing

by Alfred Cohen

Assistant Project Engineer in the Instrumentation Section of the RMI Test Department, Mr. Cohen is investigating new concepts for acquiring, reducing and evaluating test data. After graduating in mechanical engineering from City College of New York, he worked as a civilian test engineer for the Navy. Mr. Cohen came to Reaction Motors in 1954 as a Test Department Instrumentation Engineer.

Although the rocket engine in theory is an extremely simple powerplant, its development is a highly critical art. Successful operation of an engine depends upon the solution of many unique problems and the accurate measurement of unusual variables. One of the problems we encountered at RMI was the measurement of the corrosive effects of a new high energy rocket propellant, a problem we solved through the use of atomic radiation.

In determining the corrosive effects of propellants, it is essential that the sensing element employed does not come into direct contact with the propellant being tested. The propellant would rapidly damage or destroy most measuring equipment. In addition, the tolerance of the tests does not permit additional contamination from other foreign bodies.

We approached the problem on the basis that the density variation of the propellant could be the measure of its degree of corrosion upon the component materials with which it had been in contact . . . and the denser the material being tested, the less radiation would pass through it. We decided, therefore, to use the penetrating power of radiation as the tool to measure density variation.

To conduct the tests, a radioactive source and a detector for radiation were located so that the propellant being measured lay in a container between the two. The radioactive source emits gamma rays which penetrate through the propellant and its container. That part of the radiation that gets through the propellant and its container strikes the detector.

The detector contains a filling gas which is forcibly ionized when bombarded by atomic radiation. The energy of ionization is converted directly into electrical energy. Thus, an increase in the density of the propellant reduces the radiation field intensity at the detector, and results in a decreased generated signal.

However, accurate measurement of this energy is difficult because the generated signal is very low (in the magnitude of 1×10^{-13} amperes). To overcome this, an instrumentation system was specially developed to transmit, amplify and record this data.

The signal is transmitted to the amplifier by a special shielded cable that eliminates the effects of noise and other disturbances. Data is recorded by a Null system of measurement, using a ten-inch strip chart recorder. The recorder is calibrated to give full deflection for a density change equivalent to one tenth of a pound per cubic foot.

As a result of the data acquired by this test program, the research scientists have been able to improve the propellants to a point where they are both safe and highy desirable for use as rocket fuels.

This project is typical of one of the ways in which RMI Test Department supports the applied research, development and production projects associated with advanced rocket powerplants. All projects pass through this department, from the evaluation of components and fuels to the static "hot testing" of the entire engine system for an aircraft or missile before delivery.

The Test Department is staffed by a team of specialists highly qualified in mechanics, electronics, chemistry, and instrumentation. This team is constantly working to provide the most accurate possible test results and also to develop new equipment and methods that will allow for even more accurate information in the future. And—because this team is constantly expanding—we are always anxious to talk with top-rated engineers and technicians who are interested in test work.

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If you desire one or more reprints of Mr. Cohen's article, or would like to receive further information about employment at RMI, write to our Information Services Coordinator. Reaction Motors, Inc., 14 Ford Road, Denville, N. J.

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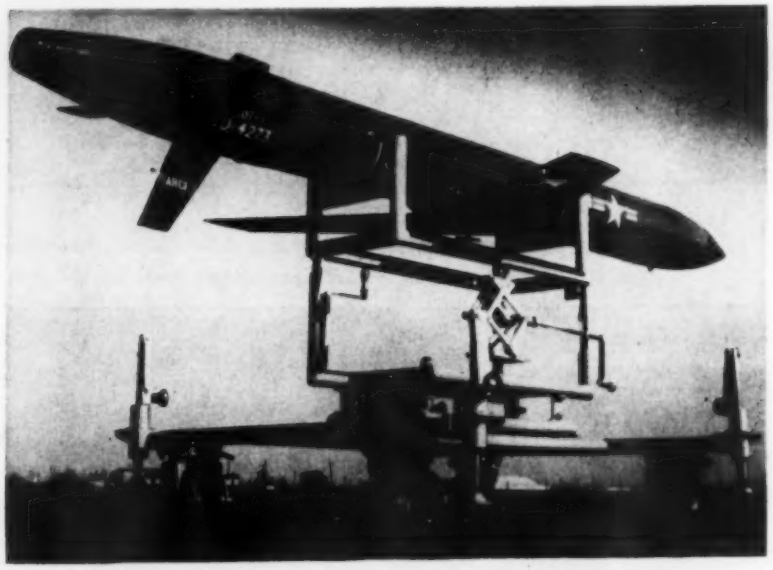
after work progressed and instrumentation became more complex.

Ground instrumentation at Wallops is virtually what it was in the beginning —the World War II tracking radar, a velocimeter, telemeter receiving equipment and radioscope facilities.

In spite of its antiquity, impressive results are obtained with this equipment, chiefly through the skill and experience of its operators. Accuracy of telemetering readings is to one degree, and for the Doppler, approximately one-fourth of one degree.

The Doppler probably has been in operation longer with more operational frequency than any other, and Operator Robert Hallett is believed to have more time logged than any other operator.

Nevertheless, the range instrumentation cannot operate beyond certain inherent limits. NACA has asked Congress in the Fiscal 1958 budget for $2.6 million for an increased range Doppler, telemetry equipment, and two new tracking radars.



Temco Reveals Drone Specifications

Temco XKDT-1 expendable target drone is 12 ft. long, has span of 58.8 in., diameter of 10 in. Speed is Mach .95 at 50,000 ft. Vertical stabilizer is belly mounted so that drone can be launched from plane. Temco has Navy contract for system.

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Powered for both loudspeaker and headphone operation, with *continuous tuning* on the three bands 190 to 440 kc; 420 to 900 kc; and 850 to 1750 kc.

10,000,000 logged flight hours behind Lear ADF design and manufacture assure the ADF-12E of even greater accuracy, smoother response, improved sensitivity, and unmatched reliability.

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POWER OUTPUT: 3 watts max.; 1.2 watts undistorted.
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The new brick-red sheath is tough, dense and compact and has high abrasion resistance. Added density throughout the insulating layers helps overcome almost all problems of compression set and there are no signs of the soft sponginess so typical of ordinary silicone cables. What's more, the insulation is non-flammable, chemically inert and has great uniformity in dielectric strength.

This new Packard Electric development was designed to meet the higher heat conditions encountered in modern aircraft. It is available in 5, 7 and 9MM sizes. No other silicone cable equals the performance of Packard's new high-heat, high-tension silicone cable. Write for information and samples. Packard Electric Division maintains branch offices in Detroit, Chicago and Oakland for your convenience.

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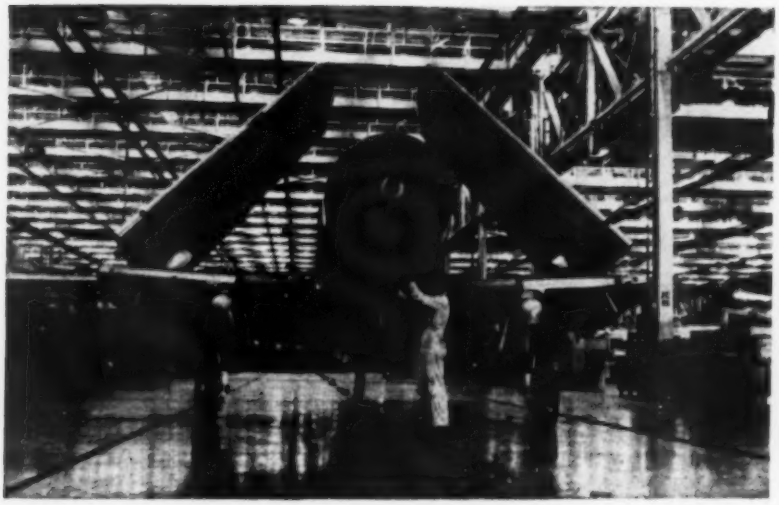
"Live Wire" division of General Motors

ADAPTABLE AD makes anti-sub team. AD-5W (lower) is detector, AD-6 attacker.



LAST Skyraider, the 3,180th, leaves Douglas assembly line at El Segundo. Model is AD-7.

Douglas Delivers Last Skyraider

Last Douglas AD Skyraider carrier-based attack bomber has been delivered to the Navy after 12 years of continuous production. Since the first prototype flew shortly before the end of World War II, 3,180 ADs have been built. They have appeared in seven dash-numbered series and 28 configurations.

Capt. James A. Thomas, Bureau of Aeronautics weapons system director, flew the last AD-7 to its new squadron. He accepted the original AD in 1945.

The AD was generally acknowledged to be the best close support airplane of the Korean War. It was capable of delivering a salvo weight equal to that of a heavy cruiser.

The basic AD day attack design was adapted as an atomic bomb carrier, submarine hunter, submarine killer, night attack bomber, electronic counter measures carrier, early warning picket, personnel and light cargo carrier, and ambulance.

Perhaps the most interesting series of ADs was the multiplex AD-5, 670 of which were delivered during 2½ years. It differed from other ADs in having a wider fuselage and bigger cockpit. Nearly 200 kits were delivered to enable squadron maintenance crews aboard a carrier to convert the day attack version of the AD-5 into a 2,000-lb. payload cargo plane, six-place personnel transport, four litter ambulance or long range bomber.

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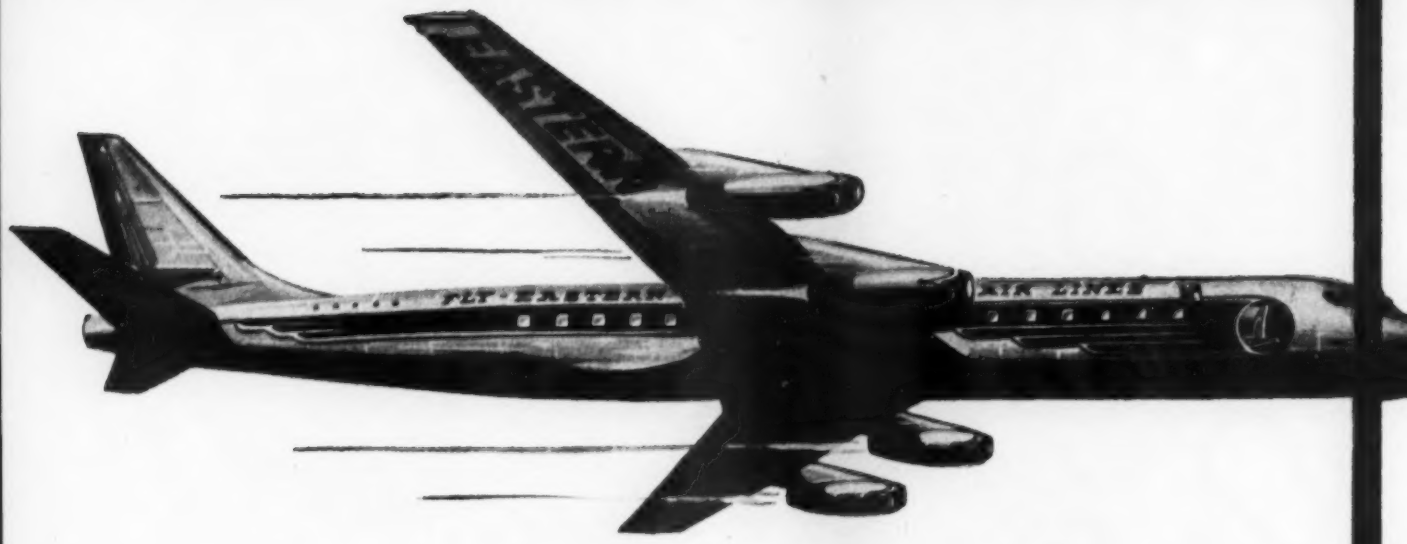

EASTERN AIR LINES

selects LINK DC-8 and

Confirming Link leadership in commercial jet simulators, Eastern Air Lines has selected Link equipment to train flight crews for their DC-8 and Electra aircraft.

Safety-minded and quality-conscious airline executives are continually studying the problem of flight training for tomorrow's jet age, and most have chosen Link.

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ELECTRA *simulators*

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Missile Hardware Contributes To Design for Space Travel

San Diego—Relation of the intercontinental ballistic missile to space conquest was pointed out by Maj. Gen. Bernard A. Schriever, commander, Western Development Division, ARDC, at a dinner gathering of scientists and engineers attending the Astronautics Symposium here. Convair and USAF sponsored the meeting.

The intercontinental and intermediate range ballistic missiles have contributed to the conquest of space in a very concrete sense from the standpoint of hardware that has been or is being developed, Schriever declared.

Out of the industrial capability being established will come a wealth of design information and hardware that will be useful for other things beyond that for which it was designed. These airframe, propulsion and guidance subsystems developments, and the data which will become available as ballistic missile flight tests are made, will make possible a whole gamut of follow-on projects, he said.

"I would be willing to venture a guess that a large percentage of the unmanned follow-on projects that one could visualize for the future can be undertaken with propulsive, guidance, and structural techniques presently under development in the Air Force Ballistic Missile Program," Schriever declared.

It should not be too difficult, he said, to extend these present developments to surface-to-surface transport of personnel by rocket propulsion, or space travel of personnel at some time in the future.

Commenting on propulsion, Schriever said:

"The same propulsive unit that

North American Muffler

Screen in muffler building of North American Aviation $5 million trisonic wind tunnel diffuses air during test blow into muffler building. Diffusion protects soundproofing materials from sudden, uneven shock. North American is spending $100,000 on soundproofing in tunnel, which will go into operation in April.

FOUR IMMEDIATE OPENINGS FOR ENGINEERS

★

Structural Test Engineer. To handle component structural tests (static and fatigue) under various environmental conditions — elevated temperatures, particularly. Experience in this field desired, but not essential.

★

Electronics Liaison Engineer. To provide engineering assistance to manufacturing and laboratory units on electronic assemblies. Degree in mechanical or electrical engineering required.

★

Senior Structures Loads Engineer. To determine air and ground loads and airframe temperature distributions; to analyze aircraft performance relative to shipboard operation; to determine repeated load criteria of aircraft components. Requires degree in engineering, applied mathematics, or physics, plus three or more years experience in aircraft loads, applied mathematics, or applied mechanics.

★

Statistical Analyst. To determine system reliability from component failure rates. Requires knowledge of statistics and probability and a degree in statistics, mathematics, or in a related field.

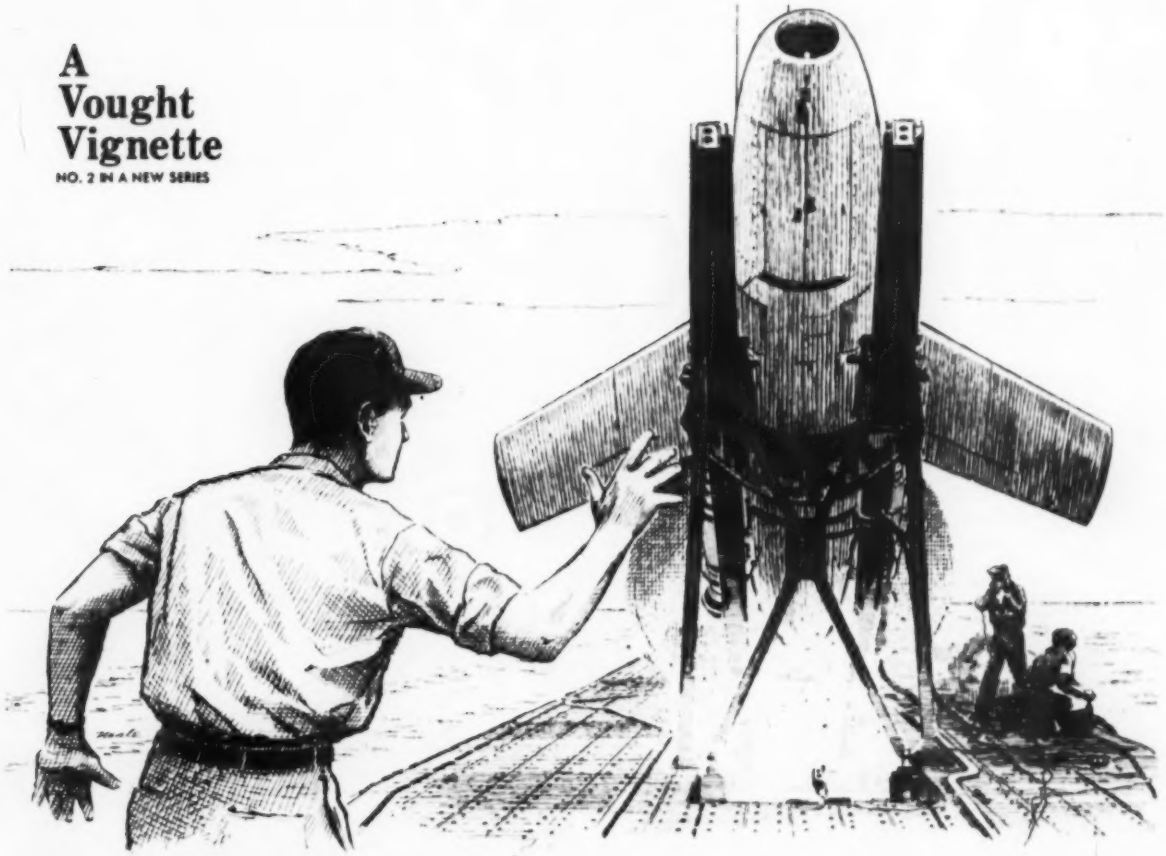
To arrange for a personal interview, or for a prompt report on these openings, write to:

Mr. J. W. Larson, Asst. Chief Engineer
Dept. A-4

CHANCE VOUGHT AIRCRAFT
INCORPORATED DALLAS, TEXAS

A Vought Vignette

NO. 2 IN A NEW SERIES



The Missile Engineer with undersea legs

Jack Welch felt honored when he was tossed, fully clothed, into the Navy's sub harbor at Port Hueneme, California. In their own rugged way, submariners were extending him their thanks. He'd been a big help in the introduction of Chance Vought's Regulus I missile to the Navy's Undersea Fleet.

Months before his ceremonial splash, Jack had accompanied the Regulus aboard the submarines *Tunny* and *Barbero* as a representative of Vought's Missile Operations Engineering Group. A veteran of the Regulus flight test program and a collaborator on the conversion of the subs to missile carriers, Jack brought knowledge the Navy welcomed. Likewise, the Navy crews were to share with Jack some equally valuable experience.

Jack, with the submarines *Tunny* and *Barbero*, cruised the East and West Coasts, performed over 200 dives, and once prowled far west of Hawaii. The missile man helped the undersea crews complete initial checkouts of Regulus support equipment — culminating in the first missile launch ever made from a submarine. Then they went about solving environmental and supply problems that arose during tests. Jack added to his mechanical engineering experience a valuable store of electrical, weapon systems and Navy knowledge.

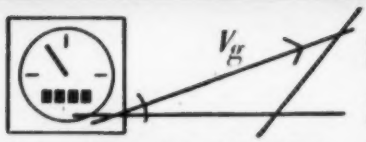
Back in home port, on the *Tunny's* quarter-deck, with a full crew assembled, submarine officers reviewed Jack's contributions. He'd gone beyond his duty as a technical advisor, they concluded. He'd become an expert submariner as well. In fact, he'd qualified for the Silent Service's Gold Dolphin insignia . . . and all hands would proceed at once with the traditional initiation. That's when Jack took his plunge.

Today, Jack divides his time between Chance Vought and a half-dozen Navy shipyards. His job is to see that current missile and ship design is meeting the missile needs of the Fleet. Problems are many, but Jack maintains there's a solution for each. "That's a lesson I learned from the submarine forces," he said. "They gave me a real indoctrination in a can-do attitude under actual operating conditions."

At Chance Vought the missile engineer belongs to a team that already has experienced every conceivable missile problem, from development to operational readiness. Here, current assignments range from theoretical work to the introduction of complete missile systems to the Fleet.

CHANCE VOUGHT AIRCRAFT

INCORPORATED DALLAS, TEXAS



Ground Speed & Drift Angle
Any Time, Anywhere, Any Weather

One look and the pilot KNOWS. In a glance he reads actual ground speed and drift angle.

This vital data, never before available, is displayed on the flight panel automatically and continuously.

The dials "read" the key unit in GPL's revolutionary Doppler auto-navigation systems. Other phenomenal units in these systems tell where you are and how to get where you're going. The systems operate entirely without ground aid or celestial fixes, have proved themselves globally in millions of operational miles.

GPL's auto-navigators were developed in conjunction with the Air Force (WADC). They are the result of GPL's harnessing of the Doppler-effect to air navigation – an achievement comparable in magnitude to the breaking of the sound barrier.

"oops! headwinds"

Spotting a headwind is easier than reading a windsock for military pilots these days.

GPL's Doppler auto-navigation systems tell them "Headwind" – and how much – the instant one appears, let them seek a more favorable wind.

Because they do, they save precious time and fuel – *and provide a priceless margin of safety.*

GPL Doppler auto-navigators are bringing about a revolution in flight. Their benefits will one day soon extend to everyone.

GPL

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GENERAL PRECISION LABORATORY INCORPORATED, Pleasantville, N. Y.

ENGINEERS – GPL achievements have opened up some unusual research and development opportunities. Send resumé to Personnel Manager.

boosts a heavy nose cone warhead to 25,000 ft./sec., could boost a somewhat lighter body to the escape velocity of 35,000 ft./sec. or to an orbital path around the earth," Gen. Schriever told the symposium.

"The same guidance missile system that enables the warhead of a ballistic missile to reach its target within a permissible accuracy would also be sufficiently accurate to hit a target much smaller than the size of the moon, even at that increased range."

New gains in the ratio of total weight to structural weight have been achieved, Schriever indicated.

Since the ballistic missile program was accelerated in 1954, $470 million has been made available for new test installations and plant expansion.

A substantial portion of this sum, over $100 million, is privately financed by both prime and subcontractors, Gen. Schriever said.

Military Aviation Funds

The military services had an unexpended balance of over $23 billion on hand as of Dec. 31 for aircraft, engines, parts and guided missiles procurement. New contracts during the first half of Fiscal 1957—July through December—reduced the unobligated balance for these procurement items to $10.5 billion (000 omitted).

OBLIGATIONS

	Obligations July 1-Dec. 31, 1956	Available For Obligation Dec. 31, 1956
Aircraft, Engines, Parts		
Air Force	$3,242,709	$5,476,782
Navy	1,230,161	1,923,091
Army	19,765	188,575
MDAP	246,887	1,064,479
TOTAL	4,739,522	8,652,927
Guided Missiles		
Air Force	888,911	1,411,562
Navy	252,904	255,090
Army	249,188	289,764
MDAP	.....	.....
TOTAL	1,391,003	1,956,416
Electronics and Communications Equipment		
Air Force	299,166	550,789
Navy	53,303	231,099
Army	61,023	105,557
MDAP	35,290	270,950
TOTAL	448,732	1,158,395

EXPENDITURES

	Expenditures July 1-Dec. 31, 1956	Available for Expenditure, Dec. 31, 1956
Aircraft, Engines, Parts		
Air Force	$2,730,841	$12,250,887
Navy	896,886	5,198,743
Army	87,648	353,421
MDAP	267,214	1,421,871
TOTAL	3,982,589	19,224,922
Guided Missiles		
Air Force	580,174	2,457,281
Navy	104,183	629,815
Army	169,104	1,056,534
MDAP	.....	.....
TOTAL	853,461	4,134,630
Electronics and Communication Equipment		
Air Force	230,914	1,298,982
Navy	56,483	388,131
Army	79,292	500,479
MDAP	88,487	295,377
TOTAL	455,176	2,482,969

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GRAY CODE MODEL – Capacity of 8 binary digits (single brush pickoff).
BINARY MODEL – Capacity of 7 to 19 binary digits.
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Units for special codes or capacities are built to meet specific requirements.

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PICKOFFS.....Multiple wire brush. Two pickoffs/channel
ROTATION.....Continuous, either direction.

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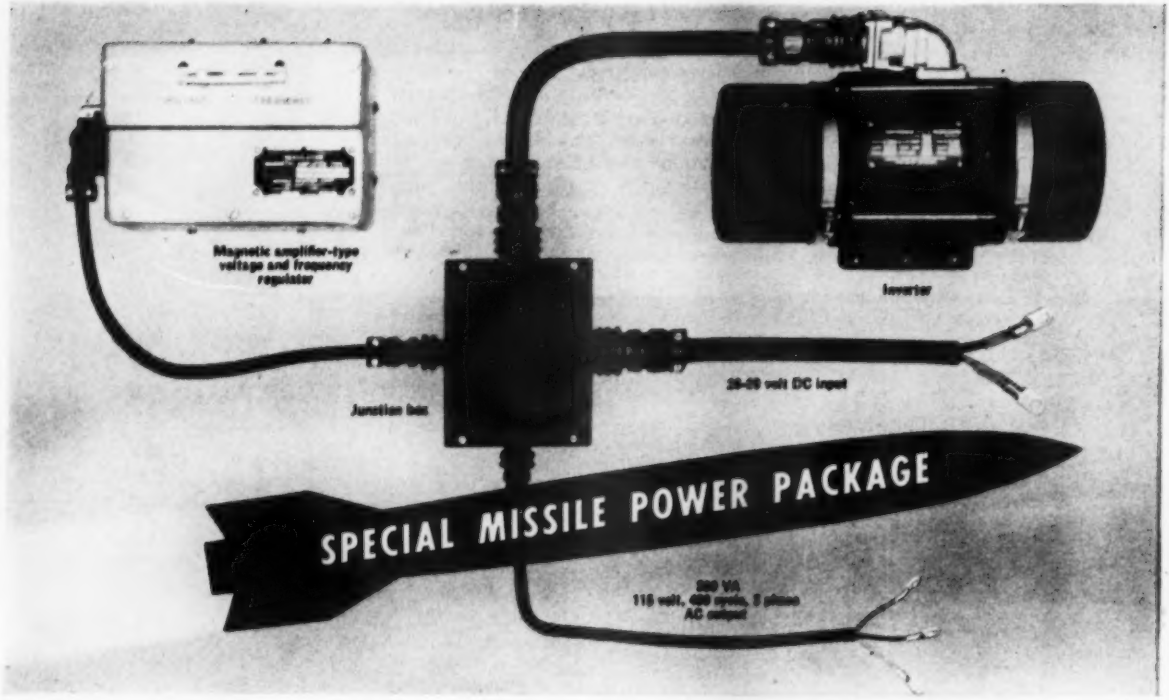


An example of the

Bendix Red Bank

complete line of high-altitude and missile inverters

As aircraft and missile performance continue to step up, Bendix Red Bank designers continue to lead the field in developing new, high-performance inverters and power packages.

We now offer a complete line of inverters from 6 VA to 5,000 VA, including advanced special-application units and missile type power packages like the one shown above.

If we don't have an inverter to meet your specific needs, we'll design one. For full details, write RED BANK DIVISION, BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

West Coast Sales & Service: 117 E. Providencia Ave., Burbank, Calif.
Export Sales & Service: Bendix International Division, 205 E. 42nd St., New York 17, N.Y.
Canadian Distributor: Avistion Electric Ltd., P.O. Box 6102, Montreal, Quebec

INVERTERS — 400-CYCLE OUTPUT

Type	Input		Rated Output			Max. Altitude at Rated Output	Approx. Wt. Lbs.	Designed to Gov't. Part No.
	Volts	Amps.	Volts	Phase	VA Rating			
12128	27.5	1	26	1	6	35,000	2.2	AN3496
12126	27.5	2	26	3	10	35,000	2.3	E1615
32B21	27.5	3	115	1	20	50,000	5	—
MG-93	27.5	12	115/200	1 3	100 100	65,000	10	E5134
MG-54	27.5	22	115/200	1 3	250 250	50,000	17	E5109
12142	27.5	22	115	1 3	250 250	35,000	13	E1617
12143-1	27.5	22	115	3	250	35,000	13	—
12143-2	27.5	22	115	1	250	35,000	13	—
*32B15	27.5	22	115	3	300	50,000	14	—
32E01	27.5	35	115	3	500	50,000	26	AN-3533-1
32E00	27.5	51	115	1 3	500 750	50,000	34	AN-3534-1
MG-65	27.5	52	115/200	1 3	750 750	50,000	35	E52805-2
MG-61	27.5	126	115	1	1750	50,000	54	53C6767
1518	27.5	126	115	1 3	1500 1800	20,000	37	—
32E06	27.5	160	115/200	1 3	2000 2250	50,000	56	E1725
32E03-3	27.5	150	115	1	2500	50,000	58	53B6227
*32E03-8	27.5	160	115	1	2500	50,000	65	53B6227
*MG-77	27.5	150	115/200	3	2500	50,000	65	—
*32B49	27.5	160	115/200	1 3	2500 2500	50,000	65	E54807
MG-81	27.5	160	115/200	1 3	2500 3000	50,000	61	E1725
MG-95	27.5	160	115/200	1 3	2500 3000	50,000	58	E54807
32E09	27.5	160	115	1 3	2500 3000	50,000	60	—
32B27	27.5	285	115/200	1 3	3500 4000	50,000	76	—

*These inverters have magnetic amplifier "static" type voltage and frequency regulators.
NOTE: D.C. Input Voltage shown is nominal value of 27.5 volts, but all units are designed for 26 to 29 volt operation. Input amperes shown are rated at 27.5 volts input.

Red Bank DIVISION — Bendix AVIATION CORPORATION

Eglin Opens Mach 3 Weapon Test Range

Eglin AFB, Fla.—Test operations have begun on a new Mach 3 damage potential range (AW Aug. 6, p. 313) at the Air Research and Development Command's Air Force Armament Center here.

The range will be used to determine damage potential, fuze functioning and crosswind ballistics of guns, rockets and medium sized air-to-air missiles.

It includes a 2,000-ft. continuously welded, single rail track and a rocket propelled sled that will simulate aircraft speeds before the test missile is fired. Targets will range from metal plates to obsolete or damaged aircraft tanks and fuselages. Speeds of approximately 2,600 mph. are expected.

Foreign Fighters Tested by Swiss

Geneva—Swiss air force has requested permission to purchase 40 to 100 foreign fighters after first making a comparison test. This follows a decision last year to develop the Swiss-designed P. 16, which resulted in the cancellation of a $25 million dollar order for 40 French Mysteres.

Foreign models under consideration are the French Mystere IVA, the Canadian Sabre Mk. 6, and the British Hunter F. 6. Mystere tests have just been completed. Those for the other two are imminent.

Swiss air force moreover requests authorization to purchase 60 Swiss-made Pilatus P. 3 training planes, 20 DH-115 British Vampire trainers and 8 helicopters, as follows:

- **Three French Djinn** 2-seaters, cost about $45,000 each.
- **Three French Alouette** 4-5 seaters, cost about $100,000 each.
- **Two American** 2 ton load helicopters capable of carrying 15 fully equipped soldiers at a cost around $500,000 each. These are probably H-21s.

Test 'Difficulties' Bring Beverley Fixes

London—Modifications are being made to the Blackburn Beverly transport aircraft to overcome "difficulties" encountered during Royal Air Force flight trials.

This was revealed to Parliament by Supply Minister Aubreyn Jones. Development "has not been more difficult than expected for a completely new engine and airframe combination," Jones said.

Nineteen Beverleys have been delivered to the RAF.

(Advertisement)

Valve Talk

FOR WM. R. WHITTAKER CO., LTD.

BY MARVIN MILES

Glen Walton can talk actuators or boats with equal ease. Vocation or avocation, it makes no difference. He lives both with enviable intensity.

A Whittaker supervisor, Glen heads up the company's electrical group, although he refers to it as a service group catering zealously to the needs of the valve and pump divisions.

"Our job," he explains, "is to develop or adapt actuators that will meet the performance and envelope requirements of the valve and pump people—and I might add that it's getting tougher every day because qualification tests are increasingly severe.

"You must remember that an actuator is more than just a motor. It also includes the gear train, disconnect mechanism, limit switches, housing, plug-in and other elements of the watch-like assembly that operates the unit. It's the mind and the sinew that makes the valve or the pump function."

Every actuator turned out by Walton's group is designed in detail, with exhaustive consideration for the voltage required, the ambient range, the time needed for operation, the torque required under specified conditions, the envelope restrictions and the tests that must be passed for acceptance.

Glen Walton
Electrical Group
Supervisor

"As aircraft and missiles fly faster, higher, and farther the requirements an actuator must meet in valve operation become more and more critical," Glen says.

"Full qualification tests must be run before production is started, including 10,000 cycles or more at full flow, ten-G vibration tests, operations in temperature ranges from minus 65 to plus 400 degrees F, trials in sand, dust, salt spray and fungus conditions and analysis of resonation qualities.

"Of these varied tests, vibration is fast becoming the roughest problem, requiring that actuators come in shorter, squatter envelopes to resist the G-effects.

"Virtually all actuators are sealed these days," he adds, "and they're tested under water with 15 pounds of air pressure to simulate high altitude conditions."

Glen, who developed the two-bar clutch, a bi-directional, rotating out-put shaft that can disengage gears and motor at any point, says that much of his group's work is adapting actuators—"small parts for bigger parts or vice versa"—always trying for a smaller, lighter unit that will do the job.

"Many actuators are adaptable to varied requirements by changing parts," he points out, "but where we really run into trouble is in tandem valves where the problems become almost limitless."

Walton was born in an Illinois whistle stop and came to Long Beach in Southern California in 1909 at the age of three. A graduate of Polytechnic High, he learned his trade the hard way, at night school and by experience in different shops.

He became a tool designer for the Axelson Aircraft Engineering Co. and later was employed by Newberry Electric in traffic signal and street lighting work for four years. Then he spent eight years with Technicolor before joining Schwein Engineering in 1943 as a tool maker.

Always interested in mechanical engineering and the design of small electric motors, Glen came to Whittaker in 1947, served a year as head of the machine shop, worked on production tooling for the company's Pixie camera—a post-war fill-in—and put together the company's first planetary actuator.

After sparking the planetary assembly line to 100 units a day, he entered research and development work on motors, electrical components and actuator assemblies. Special problems in this field were referred to Walton's skilled analysis and for a time he was doing solenoid work also, but now Whittaker purchases its solenoids outside.

You'd never take Glen for a grandfather. His appearance belies it as does his 30-foot sloop "Shady Lady," his 34 cup awards for sailing events and two Pacific Coast championships, one for the 18-foot sailing class, one for dinghy racing.

It's a moot point as to which he loves best—sails or actuators—but, up till now Glen has always been able to do full justice to both.

Bristol Asks to Build Sycamores in Australia

Melbourne—Bristol Aeroplane Co. of England has asked the Australian federal government for an arrangement to build Bristol Sycamore helicopters at the Government Aircraft Factories at Fishermens Bend, suburban Melbourne.

Bristol has told the Australian Dept. of Defense Production that it confidently expects very heavy demand for helicopters from New Guinea, New Zealand, Indonesia, Borneo and several other countries in relatively close proximity to Australia. Bristol also expects an expanding demand from Australian sources, including, perhaps, additional helicopters for armed forces.

It is understood that Bristol's U. K. factory is finding it rather difficult to meet the demand and is afraid that delivery delays will cause the transfer of orders to other manufacturers.

Air Force Increases SM-64 Navaho Funds

Downey, Calif—USAF awarded an additional $1,082,670 to an existing contract in SM-64 Navaho program to North American Aviation's Missile Development Division.

Supplemental contract is for improvements to government-owned Downey plant where X-10 test missile for Navaho was produced.

USAF is terminating part of second stage test vehicles, GM-26, no longer necessary in the program.

Company has been instructed to divert materials to more advanced stages, which are configuration for the Navaho.

Boeing Engineers Seek 'Leveling' End

Professional engineering associations with an announced membership of 6,500 Boeing engineers have presented the Boeing Company with a proposal which would virtually eliminate salary "leveling."

An almost universal complaint among engineers, salary "leveling" refers to the practice of annual raising the starting salaries of new graduates without comparable increases for experienced engineers.

The new proposal calls for an automatic yearly rise in all Boeing engineering salaries by the same percentage that beginning salaries had increased during the previous year.

This plan was presented during the current negotiations between the company and the engineering associations, the Seattle Professional Engineering Assn., and the Wichita Engineering Assn., both affiliated with the Engineers and Scientists of America.

Jet Provost Ordered In Quantity for RAF

London—Hunting Percival Jet Provost basic trainer has been ordered into quantity production for the Royal Air Force.

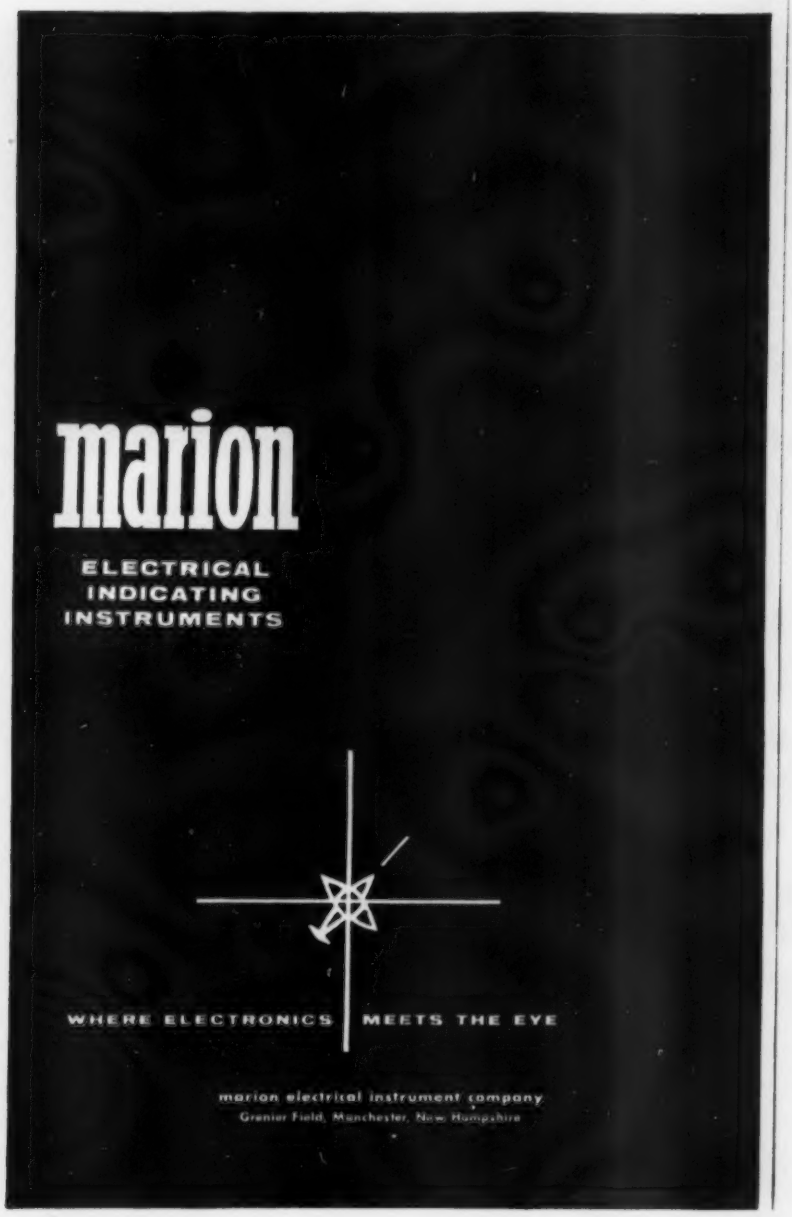
Provost is powered by an Armstrong Siddeley Viper ASV 8 turbojet with 1,750 lb. static thrust.

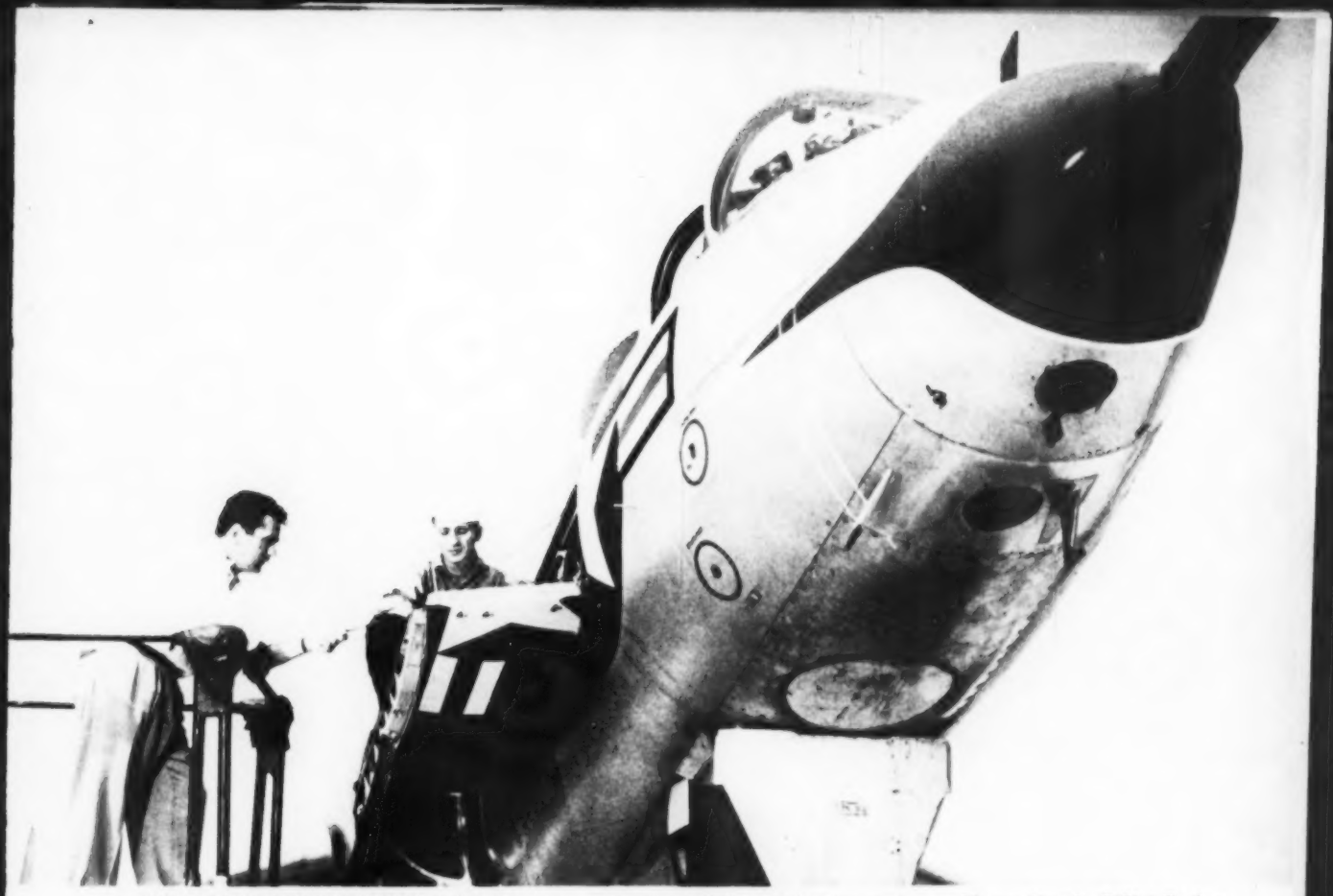
Ordering of the Provost marks a decision by the RAF to use jet aircraft for all-through flying training, first air force in the world to do so.

Secretary of State for Air George Ward says:

"Various evaluation trials have shown that 'Ab Initio' flying training on jet aircraft has definite advantages, and it has therefore been decided to establish this form of training on a larger scale.

"A production order is now being placed for the Jet Provost, which I am satisfied is the best aircraft for the purpose."





NAVY AVIATION ELECTRICIAN and G-E "tech rep" check out flight stabilization system on Chance Vought F7U-3 Cutlass.

How on-the-spot service engineers back up General Electric flight control systems

G-E SERVICE ENGINEER, Willie Jaques, demonstrates the autopilot line maintenance tester to Navy aviation specialists.

G E field service engineers provide valuable technical assistance to the Armed Forces wherever service is required on General Electric flight control systems. These "tech reps" also conduct classes for pilots and aviation specialists on the operation and maintenance of G E flight control systems.

In addition, General Electric service engineers make detailed field operation reports on flight control system performance. These reports provide design engineers with information on system performance on operational aircraft for improving future G E flight control systems systems that are now being designed and built for the latest supersonic aircraft.

FOR DETAILED INFORMATION on the flight control systems that General Electric is designing and manufacturing for our Armed Forces, contact your G E Aviation and Defense Industries Sales Office. Section 221 9, Schenectady 5, New York.

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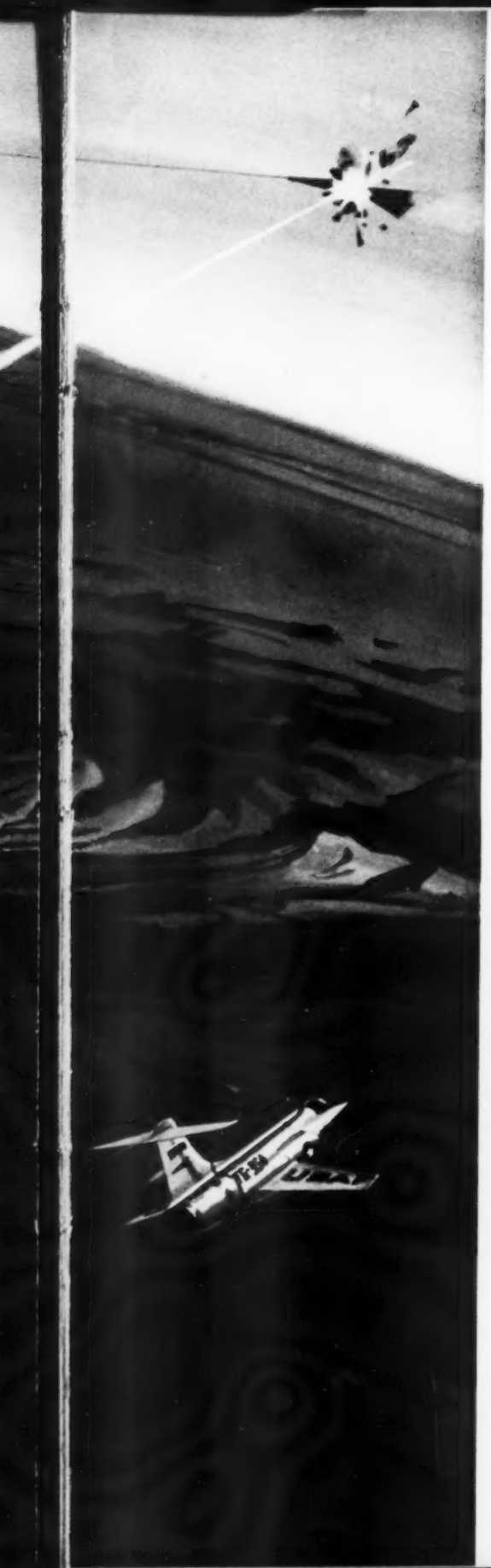

VULCAN !

How New 6-Barrel Aircraft Gun Designed by General Electric Improves Fighter Effectiveness

Literally tearing to pieces a supersonic tow target is a dramatic demonstration of Vulcan's fantastically high rate of cannon firepower. Developed by General Electric, at the request of the U.S. Army and to U.S. Air Force specifications, Vulcan is the most potent machine gun available today.

Exactly how fast it will fire is still classified, but it has been said that Vulcan can fire more rounds in 60 seconds than an infantry company can shoot in 20 minutes. Installed in the Air Force's newest supersonic fighters, Vulcan gives America's airborne defenders the quick and heavy counter-punch necessary for defense against supersonic aircraft.

To provide our Armed Forces with the complex equipment needed to keep the peace is an accepted responsibility at General Electric. As we see it, progress in developing advanced defense techniques is vital to the future security of America. General Electric Co., Schenectady 5, N. Y. 221-16

VULCAN'S SIX-BARREL CLUSTER is externally powered to achieve a high firing rate and unprecedented reliability. In the latest model, G-E engineers were able to cut the gun weight to less than 50% of the original government design objective.

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GENERAL ELECTRIC

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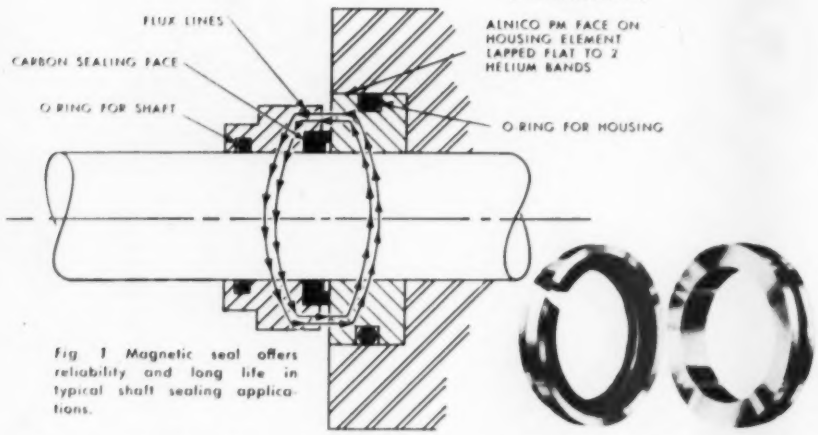
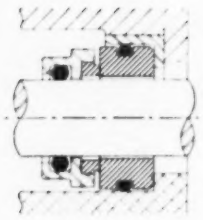
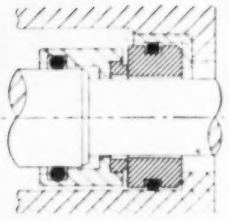

FLUX LINES
CARBON SEALING FACE
O RING FOR SHAFT
ALNICO PM FACE ON HOUSING ELEMENT LAPPED FLAT TO 2 HELIUM BANDS
O RING FOR HOUSING

Fig. 1 Magnetic seal offers reliability and long life in typical shaft sealing applications.



LOW PRESSURE MAGNETIC SEAL



HIGH PRESSURE MAGNETIC SEAL

Aircraft Shaft Sealing Problem Solved Through Magnetics

Force and wear are distributed evenly over entire face of new, effective, long-lasting magnetic shaft seal. Troublesome springs and packing are eliminated.

By Edward A. Steeves
Member, ASME

One of the most difficult problems in designing the powered elements of aircraft is sealing shafts against the loss of fluids, or their passage into areas where they may contaminate vital operating parts. A wide variety of fluids must be sealed: fuels, lubricants of various types, hydraulic fluid, and others, under severe operating conditions.

In addition, the customary factors of space and weight must be given full consideration.

By applying magnetics to this problem, designers have come up with an effective solution. The magnetic shaft seal takes minimum space because springs and packing are replaced by magnetic attraction between the shaft and housing elements of the seal. Force is distributed evenly throughout the metal, so wear is slow and even, and the seal *Fig. 1* performs reliably for much longer periods than spring-loaded and packed seals.

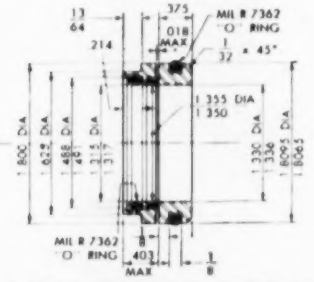


Fig. 2 Typical application of magnetic shaft seal in aircraft generator. Rotational speeds do not impair effectiveness of seal.

Operating Principle

New concept in shaft sealing for aircraft applications uses magnetic force to replace springs and screws to hold shaft and housing elements together.

A magnetized ring of Alnico V, with an O-ring gasket on its outer surface, is inserted in the housing. Another ring is mounted on the shaft and held firmly against the Alnico element by magnetic force. A carbon ring in the face of the shaft element contacts the lapped surface of the magnet and forms a permanent, self-adjusting face seal.

An O-ring mounted inside the shaft element prevents the confined fluid or gas from escaping along the shaft. The O-ring on the magnetic element keeps the fluid from leaking out the housing.

Advantages of Magnetic Shaft Seals

Reliable, effective sealing is characteristic of the magnetic shaft seal. One of the elements of the seal is permanent magnet, so the sealing force is "built in". No springs or screws are required . . . the sealing force is evenly distributed over the faces of the seal. There's no face leakage initially, and the seal "wears in" over its entire life . . . in many cases longer than the life of the shaft.

It is more compact and lighter in weight than any conventional seal.

The carbon sealing face is self-lubricating — runs cool and wears slowly.

Typical Application of Magnetic Shaft Seal

Jack & Heintz, Inc., struck a serious sealing problem in an aircraft generator. Generator cooling oil could contaminate the brushes and cause generator failure unless the shaft were effectively sealed. Operating conditions called for a rotational speed of 12,000 rpm. Although the shaft measured 1.312 in. dia., only minimum axial space was available for the seal.

The solution was found in the magnetic shaft seal illustrated in *Fig. 2*. Effective, positive face sealing at high rotational speeds proved to be the ideal solution, yet the space required was held well within the design requirements. The result is reliable, effective seal, and clean generator brushes between overhaul periods.

Specifications of Generator Shaft Seal

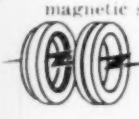
Fluid or Gas	Outside Air	Inside Lubricant Mil L-7808
Pressure (max.)	15 psi	Variable
Temp. F (max.)	300	——

Shaft Dia. (in.) 1.312
Material Steel

Additional Technical Information is Available

Send for our complete brochure on magnetic shaft seals.

magnetic seal corp.



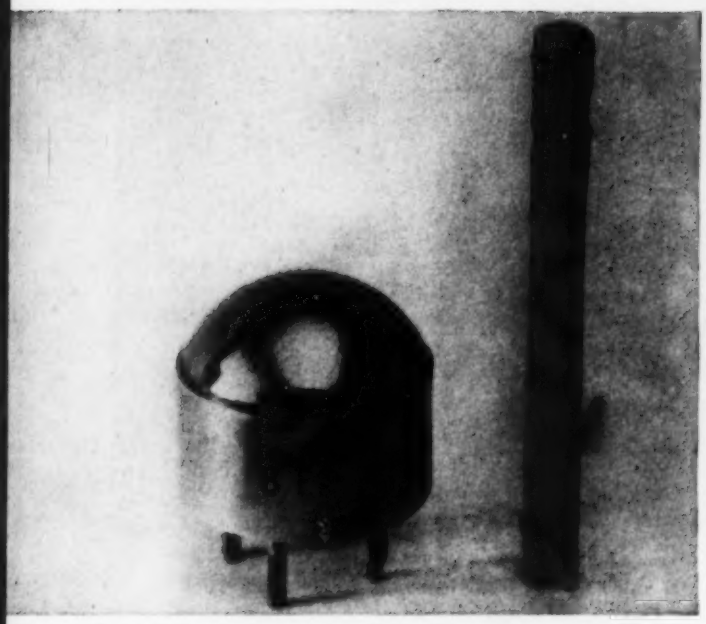
SOWAMS ROAD
BARRINGTON, R. I.

LOW vibration level is reported in first test flights of Omega Twin SB-12 helicopter. Engines are two Aircooled Motors 6A-335s developing 210 hp. each. All vibrating components are thoroughly isolated in light-weight flying crane. Reliability, ease of maintenance are stressed (AW May 7, 1956, p. 50).

Omega Flies Twin-Engine SB-12 Helicopter

ROTOR head and control linkages of Omega Twin are designed for quick disassembly with standard hand tools. Maintenance philosophy calls for field replacement and bench repair of components. Belt-drives isolate engine vibration.

SB-12 will be first twin certificated by CAA. Engines, outriggers are swept aft to avoid resonance of parallel shafts. It has working parts separated in low density design for easy access to maintenance jobs.



INFRARED detector, which converts IR radiation into electrical signal, forms heart of all infrared systems. Thermal cell (left) has wide spectrum response but low sensitivity. Photoconductive cell (right) has higher sensitivity but only over limited band.

Exclusive Report on Infrared: Part II

IR System Designer Faces Many Hurdles

By Philip J. Klass

One of the most challenging aspects of infrared system design is the fact that the designer has no control over two key parameters affecting system performance and relatively little control over a third.

This is in contrast to the radar system designer who has relatively wide latitude in selecting system parameters such as frequency, power, pulse length and repetition rate to optimize performance.

The three key parameters in IR system design are:

• **Target and background** radiation characteristics.

• **Heavy atmospheric attenuation** in certain portions of the IR spectrum.

• **Responsivity** of infrared detectors which convert IR energy into low-level electrical signals.

These factors are important in all types of infrared systems, which can be broadly divided into two basic categories:

• **Detection**: This type of IR system must be able to detect its desired target and discriminate between it and background radiation from unwanted objects. Typical applications include missile guidance, bombing, gunsights, and early warning.

• **Mapping**: This type of system provides a visual scope-type presentation or photograph of the area under surveillance delineating between objects of different temperatures. For such use the IR system must be able to measure the intensity of IR radiation from a variety of objects over a band of wave lengths corresponding to their range or temperatures.

Target Radiation

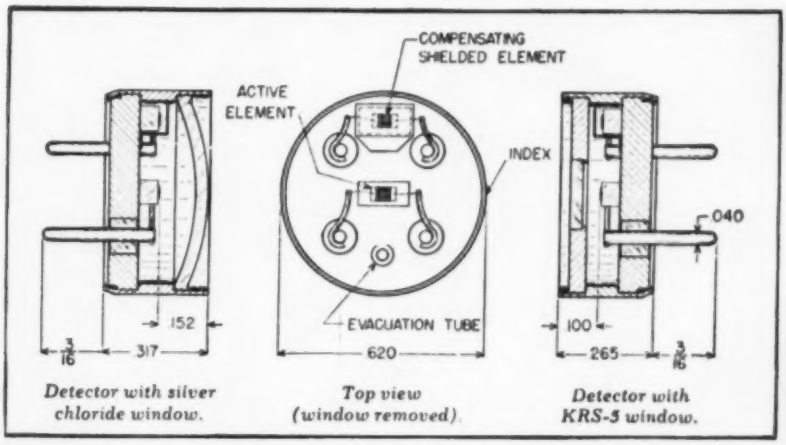
One of the first steps in the design of any infrared system is to determine the radiation characteristics of the target and its background, including:

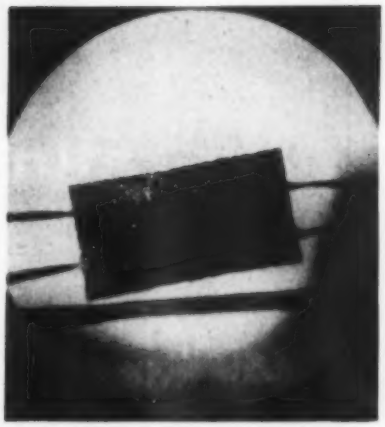
• **Peak radiation wave length.** The target's absolute temperature (in degrees Kelvin) determines in which portion of the infrared spectrum its maximum radiated energy occurs. This broadly establishes the part of the infrared spectrum in which the system designer must operate, as well as the type of detector that will be used. The higher the temperature, the shorter the wavelength (approaching visible light). For example, an object at 300C emits its peak infrared energy at a wavelength of about five microns (0.0005 cm.) while an object at 100C peaks at about 7.8 microns.

However, the IR energy radiated by a jet exhaust or rocket engine plume has very narrow spectral radiation bands whose wavelength is determined by the characteristic molecular resonance of the products of combustion. For example, the carbon dioxide and moisture in a jet exhaust create radiation at 2.5-3.2 and 4.2-4.5 microns respectively.

• **Radiated energy level.** Total infrared energy radiated at all wavelengths increases as the fourth power of an object's absolute temperature. But the intensity of the energy emitted at the peak radiation wave length increases as roughly the fifth power of absolute temperature. Thus if one object is at twice the absolute temperature of a second object, it will radiate 16 times as much infrared energy at all wave lengths, but in the region of its peak radiation wave length it will emit roughly 32 times as much infrared energy as the cooler object.

• **Emissivity.** Infrared energy that an object theoretically can emit is a function of its absolute temperature, but the amount that it actually does radiate depends also on its surface finish. The smoother and more shiny its surface, the smaller the percentage of potential infrared energy radiated at any given temperature. For example, an airplane with highly polished skin will radiate only about 10% as much energy as a night fighter whose skin is painted





THERMAL detector consists of two tiny flakes of thermistor material (shown right alongside human hair for comparison.) Resistance of one flake changes as infrared radiation strikes it. Other flake is shielded to provide ambient temperature compensation.

black, if both have identical skin temperatures. "Emissivity" is a term used to express an object's radiating efficiency, i.e. the ratio of its radiated energy to that which it would emit if it were an ideal "black body." The emissivity ratio, or factor, is always less than unity and must be used in any analytical determination of target radiation as shown below, in what is known as the Stefan-Boltzmann Law:

$$W = \epsilon \sigma T^4$$

Where:

W = Total radiated energy per unit target area

ϵ = Emissivity factor

σ = Stefen-Boltzmann constant (5.7×10^{-12} watts/Cm.^{2} Deg.^{4})

T = Absolute temperature (degrees Kelvin)

Thus an object at a temperature of 900C would radiate approximately 10 watts/sq. cm. if its emissivity were 0.95, but only 1.05 watts/sq. cm. if its emissivity were about 0.1.

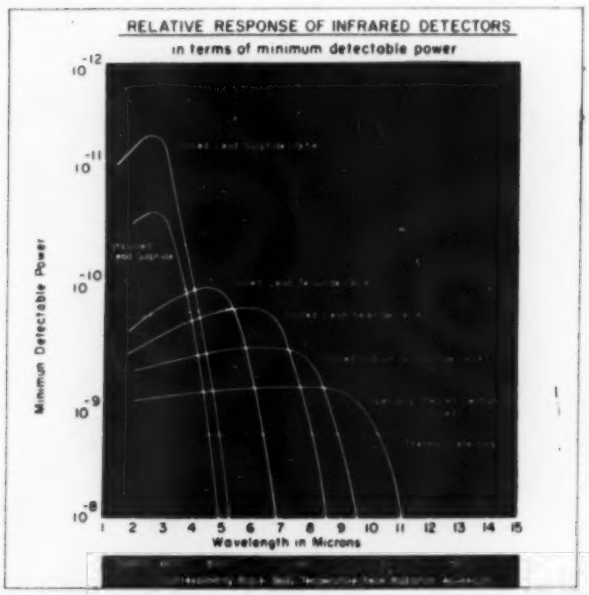
Distance Effects

The above equation describes the infrared energy level at the target, not that which reaches an infrared system detector some distance away. Neglecting the effects of atmospheric attenuation, the energy available at a remote IR detector varies inversely with the square of the distance between the target and the detector, similar to the variation of visible light intensity with distance.

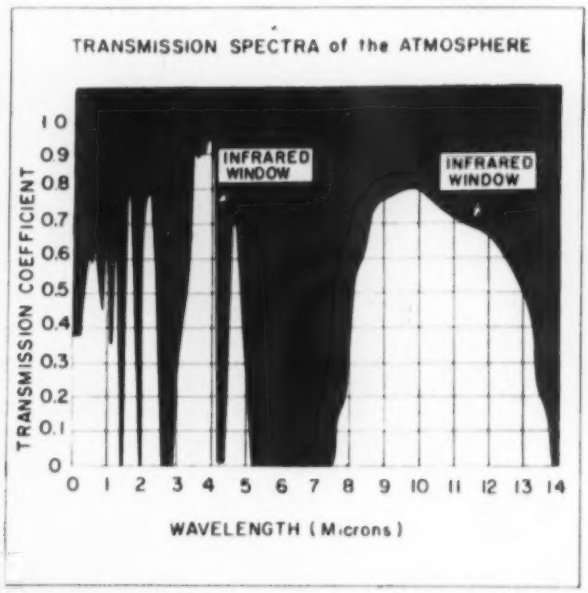
At one mile, a target at 900C with an emissivity of 0.1 would produce incident energy at a detector of approximately 10×10^{-12} watts (ten micro-micro-watts) per square centimeter of detector area for every square centimeter of radiating target area. (This neglects the effects of atmospheric attenuation and of optics used to collect and concentrate infrared energy at the detector.) At a distance of 100 mi., the incident energy level would fall to 10×10^{-16} watts/cm.^{2}.

Atmospheric Attenuation

Unfortunately for the infrared system designer, nature intervenes to reduce seriously the amount of energy actually available at the detector for certain parts of the spectrum. Moisture and carbon dioxide in the air attenuate and/or scatter infrared energy sharply in some parts of the spectrum, less heavily or


RELATIVE RESPONSE OF INFRARED DETECTORS
in terms of minimum detectable power
Minimum Detectable Power
Wavelength in Microns

DETECTOR bandwidth varies inversely with sensitivity.



ATMOSPHERE heavily attenuates infrared in certain bands.

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not at all in others. In this respect, the atmosphere acts somewhat like an electrical filter in passing certain frequencies, rejecting others, except that the amount of attenuation will vary with the amount of moisture in the air.

Parts of the spectrum which readily pass infrared energy without serious attenuation are called "windows." At or near sea level, the most transmissive of these infrared windows occur at approximately the following wave lengths (corresponding peak radiation temperature shown in parentheses):

- **1.5 to 1.8 microns** (1,650 to 1,350C)
- **2.1 to 2.4** (1,100 to 920C)
- **3.3 to 4.2** (600 to 410C)
- **4.5 to 4.8** (370 to 330C)
- **8.0 to 13.0** (90 to −50C)

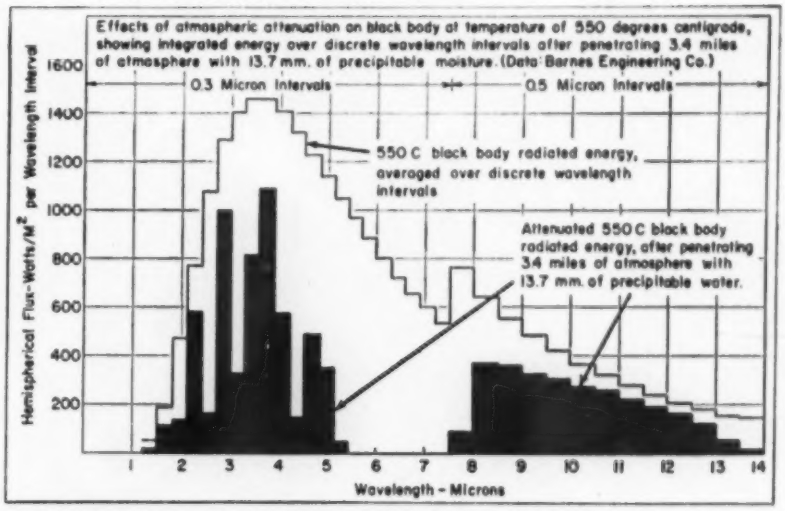
At altitudes above sea level, the band width of the infrared windows increases because of reduced air density and moisture.

At altitudes of 30,000 ft. and above, infrared suffers practically no attenuation except for a narrow chunk of spectrum centered about 2.8 microns and another at about 4.4 microns, corresponding to the carbon dioxide and moisture absorption bands.

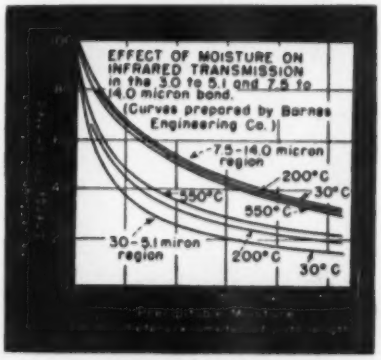
No Altitude Problem

For high-altitude, air-to-air combat, atmospheric attenuation has little or no adverse effect on infrared system performance, thereby easing the designer's task. But for many other applications, such as airborne bombing, mapping, or ground-based detection of high-flying targets where infrared energy must travel through air and moisture, atmospheric attenuation further limits the portion of the spectrum in which the infrared system designer can work effectively.

An ideal situation exists when the target's temperature is such as to make its peak radiation occur at a wave length that coincides with one of the atmosphere's infrared windows. If, however, the designer must detect an object whose temperature for example is about 200C, he finds that its peak radiation occurs at 6 microns where infrared attenuation is heaviest.


Effects of atmospheric attenuation on black body at temperature of 550 degrees centigrade, showing integrated energy over discrete wavelength intervals after penetrating 3.4 miles of atmosphere with 13.7 mm. of precipitable moisture. (Data: Barnes Engineering Co.)
0.3 Micron Intervals
0.5 Micron Intervals
550 C black body radiated energy, averaged over discrete wavelength intervals
Attenuated 550 C black body radiated energy, after penetrating 3.4 miles of atmosphere with 13.7 mm. of precipitable water.
Hemispherical Flux-Watts/M² per Wavelength Interval
Wavelength - Microns

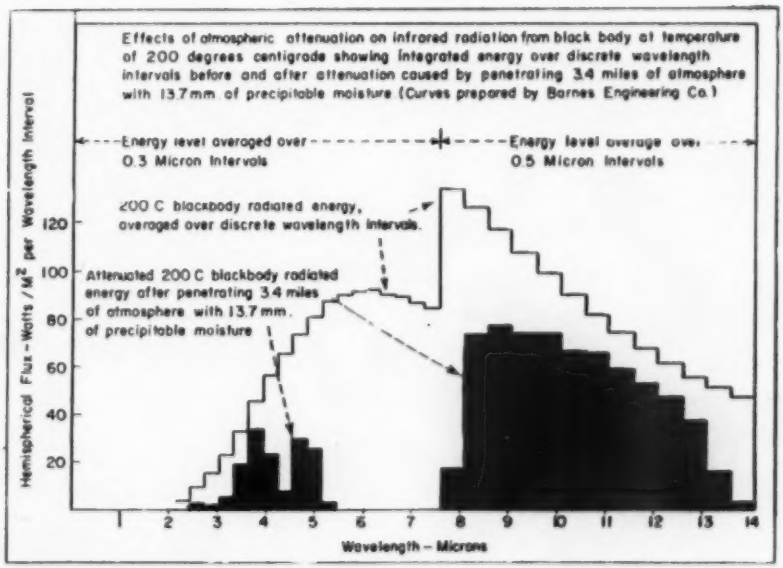
550C black body infrared radiation before and after atmospheric attenuation.



IR energy passing through atmosphere is attenuated by moisture.

The second set of curves, for a black body at a temperature of 200C, reveals that after penetrating 3.4 mi. of atmosphere with 13.7 mm. of precipitable moisture the bulk of the energy available to the detector is in the 8 to 13 micron region, although there is some energy in the 3.3 to 5.1 micron band.

If infrared detectors were broadband devices with extremely good sensitivity over a range of wave lengths, and if there were no problem of discriminating between target radiation and that from other objects, the loss of most of the target's radiated energy in certain spectrum bands would not pose too serious a problem. Unfortunately, infrared


Effects of atmospheric attenuation on infrared radiation from black body at temperature of 200 degrees centigrade showing integrated energy over discrete wavelength intervals before and after attenuation caused by penetrating 3.4 miles of atmosphere with 13.7 mm. of precipitable moisture (Curves prepared by Barnes Engineering Co.)
Energy level averaged over 0.3 Micron Intervals
Energy level average over 0.5 Micron Intervals
200 C blackbody radiated energy, averaged over discrete wavelength intervals.
Attenuated 200 C blackbody radiated energy after penetrating 3.4 miles of atmosphere with 13.7 mm. of precipitable moisture
Hemispherical Flux - Watts / M² per Wavelength Interval
Wavelength - Microns

200C black body infrared radiation before and after atmospheric attenuation.

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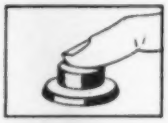

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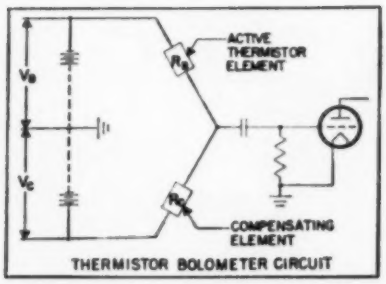

BASIC circuit configuration used with thermal bolometer infrared detectors.

detectors exhibit either relatively high sensitivity over only a limited part of the spectrum, or they cover the entire spectrum but their sensitivity is comparatively low.

Infrared Detectors

Nearly all of the passive infrared systems designed for use in an airborne or military environment employ one of the two following types of detectors:

• **Thermal (bolometer),** which contains a tiny black-coated flake of thermistor material less than 10 microns thick. Infrared energy striking the thermistor flake, is converted into heat which markedly changes its resistance. In practice, two sensitive thermistor flakes are used, connected in a bridge circuit with equal bias voltages applied. One of the flakes is exposed to infrared radiation while the second, shielded from infrared, provides compensation for changes in ambient temperature. Companies that manufacture thermal bolometer type detectors include: Barnes Engineering, Bulova Watch, and Servo Corporation of America.

• **Photoconductor,** which employs a tiny semiconductor crystal that absorbs photon energy from infrared radiation, producing a change in its resistance, or conductivity. Typical semiconductor materials used include lead sulphide, lead telluride, lead selenide, indium antimonide and a new type of specially treated germanium. Companies that manufacture photoconductor infrared detectors include: Eastman Kodak, Electronics Corporation of America, Farnsworth, Minneapolis-Honeywell, Santa Barbara Research (recently purchased by Hughes Aircraft), and Texas Instruments. Syracuse University, Michigan University and the Battelle Memorial Institute are active in photoconductor cell research.

The thermal (bolometer) type detector has the significant advantage, for certain applications, of being equally responsive to infrared radiation of any wave length. However, a thermal detector requires at least 100 times as much infrared energy as a lead sulphide photoconductor cell to produce the equivalent output signal.

This disparity would probably have eliminated the thermal detector long ago were it not that photoconductors are sensitive only over a comparatively limited band of wave lengths. For example, the curves on page 79, which compare the relative sensitivities of different types of cells, indicate that the response of lead sulphide at room temperature falls off sharply above a wave length of 3 microns. Above a wave length of about 4.0-4.5 microns, lead sulphide sensitivity drops below that of a thermal detector.

Cooling Helps

The sensitivity and spectral response of photoconductor cells can be increased by reducing their temperature. For example, cooling a lead sulphide detector with dry ice down to a temperature of about −80C (193K), pushes out its spectral response by approximately 0.5 micron and increases its effective sensitivity by more than a factor of 15. However, this gain is achieved at the expense of the detector's frequency response, that is, speed at which the detector responds to radiation.

Lead sulphide is one of the oldest types of infrared detectors, having been developed to a relatively high state by the Germans during the last war. Other materials, such as lead telluride and lead selenide, developed during and since the war, exhibit spectral response at longer wave lengths then lead sulphide, but at some sacrifice in sensitivity.

Cooled lead telluride cells at 90K are sensitive to beyond 7 microns, and cooled lead selenide to nearly 8 microns. Peak sensitivity of cooled lead telluride is only about 10-20% of lead sulphide, and the sensitivity of lead selenide is only half as great as lead telluride.

Still newer materials, indium antimonide and a specially treated germanium, are pushing the response of photoconductive cells out to nearly nine microns, but with corresponding decreases in cell sensitivity.

Which Type Detector?

For an infrared system designed to detect an aerial target whose temperature is about 550C, with peak radiation near four microns where the atmosphere has good transmissability and where the photoconductor cell has good sensitivity, the latter would be the logical choice over a thermal detector for most applications.

For a target at 200C whose peak infrared radiation occurs at about six microns, where even the newer photoconductors have relatively low sensitivities, the choice of detector is not necessarily the obvious one of a thermal type.

The designer must take into account both the relative detector sensitivities (output volts per watt of IR energy) and

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the total amount of energy available over as much of the spectrum as can be used without picking up undesired background radiation.

A thermal detector could operate over the entire IR spectrum and thus would have about 720 watts per square meter available to it (after penetrating 3.4 miles of atmosphere with 13.7 mm. of moisture). The photoconductor would have only about 140 watts available to it if the full 3-5 micron regions energy can be utilized. The question then is whether any of the available photoconductors can compensate for this 5:1 energy level disadvantage.

Lead Telluride

At first glance the lead sulphide detector, with sensitivity 100 times greater than the thermal detector, looks attractive. However, its sensitivity falls off sharply above three microns and by four microns is below that of a thermal detector. Analysis of the IR energy available below a wave length of 3-3.5 microns from a 200C target under the above conditions shows that a lead cell is not a logical choice.

A lead telluride detector is a more attractive prospect. While its maximum sensitivity is lower than lead sulphide, it still is 10 times better than a thermal detector and its response is good out to five microns when it is cooled to—180C.

Thus a cooled lead telluride detector can generate two or three times as great a signal from IR energy available in the 3-5 micron band as a thermal detector operating with five times as much energy available over the entire spectrum.

However, lead telluride and many other photoconductors are responsive only when cooled to extremely low temperatures, which adds cooling equipment weight and complexity. The IR system designer must therefore weigh the advantages of increased signal strength against the resulting cost and complexity of cooling. For some applications this might swing the decision to a thermal detector.

Background radiation from blue sky, clouds or other objects must also be considered. In mapping type IR systems, a complete "thermal picture" of all objects is presented and the human eye and brain perform the function of discriminating between the target and background, based on size, shape or radiation intensity. But in IR guidance systems, choice of operating spectrum must take into account the spectral characteristics of background radiation and/or unwanted objects. (A cool object with a warm background is as good an infrared target as a hot object in a cool background. The important factor is contrast.)

Consider, for instance, the problem of distinguishing between IR radiation from an airborne target and that from blue sky (due to atmospheric scattering of the sun's radiation). Blue sky radiation decreases with the fourth power of wave length so that it exists largely in the very short wave length region. Beyond about four microns there is practically no blue-sky radiation.

Under these conditions, an IR system designer would use filters to reject radiation below about four microns even when the target temperature was such that its peak radiation also occurred below four microns. There would still be considerable target energy available beyond four microns while the blue-sky radiation would be almost non-existent.

Jet engine exhaust gases exhibit strong IR radiation only in very narrow spectral bands, unlike black or gray body radiators. One band, at about 2.5-3.2, results from carbon dioxide in the jet exhaust; the other, at about 4.2-4.5 microns, results from moisture. Thus an air-to-air missile with IR guidance system might use filters to reject wave lengths below four microns (to eliminate blue-sky radiation) and above five microns so it will seek out only the radiation from a jet exhaust.

Jet exhaust radiation, an ideal target at higher altitudes, becomes less attractive at lower altitudes and longer distances because it occurs at wavelengths which are heavily attenuated by the atmosphere.

Target Discrimination

Where the temperature of the target is approximately the same as that of unwanted nearby objects, or their reflected infrared radiation has similar spectral characteristics, some other approach must be used to discriminate between target and unwanted objects.

In such cases the system designer must make use of other basic differences between target and background, such as size. A bomber subtends a smaller angle than a cloud formation in the "eyes" of a infrared-guided missile.

Most infrared systems used for detection, fire control or guidance employ a scanning system not unlike those used in radar which enables the detector to "look" at different portions of the area under surveillance in order to pinpoint the target's location.

If an opaque shade, whose size corresponds to that which a target of the desired size (such as a bomber) should subtend at the detector is periodically interposed between the detector and its field of view, it largely will block off infrared radiation from any object whose size differs from that of the desired target. If infrared radiation still reaches the detector under such conditions, the radiation source must be one with a much larger area (such as a cloud) and hence is not the desired target.

This technique of signal modulation for target discrimination is only one of

many which can be employed, some of them involving considerable optical and electronic sophistication.

The speed with which a detector responds to infrared radiation becomes an important factor in most military systems where the detector does not have an unlimited time to "look" at any one portion of the area under surveillance.

The detector's time constant (time required to develop 63% of its maximum output signal) is a fundamental consideration in determining system parameters, such as the maximum area scan rate. This determines the minimum time in which a given area can be scanned by an infrared system—an important factor in most military systems.

The thermal bolometer type detector, which must first convert infrared radiation into heat, is generally slower in response than the photoconductor type of cell. One way to reduce the bolometer time constant is to reduce the size and/or thickness of its thermistor flake. Barnes Engineering, for example says it produces bolometers with sensitive area dimensions as small as 0.1 mm. and with time constants as short as 200 microseconds, but most thermistor detectors have time constants in the order of 2-5 milliseconds. The lead sulphide detector has a time constant in the order of 200-400 microseconds, cooled lead telluride and selenide have time constants of about 20 microseconds, and cooled indium antimonide has a time constant of only two microseconds. Increases in detector sensitivity usually are accompanied by increases in time constant.

One way around the limitation imposed by detector time constant, for certain applications such as mapping, is the use of multi-element arrays or mosaics of detector elements. These are made both in the thermal and photoconductor types. However, maintaining uniformity between individual cells in tiny mosaics plus the multiplicity of amplifiers required, are problems arising from this approach.

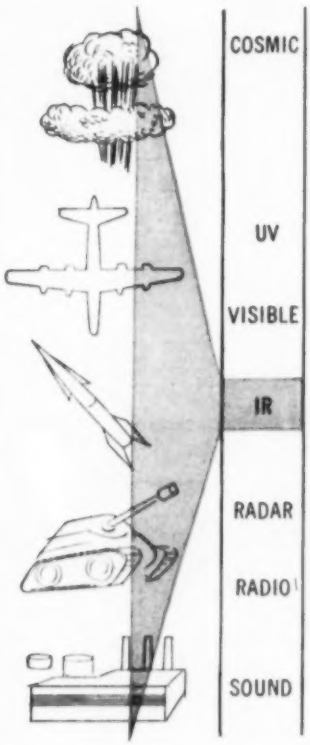
Detector Noise

An equally important consideration in selecting an infrared detector is its noise level. In the case of a thermal type detector, the output signal is generated by a change in the level of the bias current flowing through its thermistor flake due to changes in thermistor resistance resulting from infrared heating. The larger the bias voltage that can be applied to the thermistor flake, the greater the increment of change in current level and hence the greater the detector's output signal.

The limiting noise in such thermistor detectors is called "Johnson noise," which results from thermal fluctuations

Vestigia Energae Remanent

A science dating back to the Romans . . . rapidly advanced through modern research techniques . . . infrared now offers significant new answers to many military problems. A natural supplement to radar and optical physics . . . the use of infrared for detection purposes has been influenced basically by these factors:



All objects are natural radiators of infrared energy whenever molecular motion exists.

The more active the object . . . the more radiation. So, fission and fusion processes, jet engines, solid and liquid propellants, aerodynamic surfaces, reciprocating engines, combustion products, heavenly bodies, the horizon, and the earth itself are all substantial infrared radiators.

The present State of the Art permits the detection of objects having temperature differences of only a few degrees and also those as far away as 500 light years. These IR systems are suitable for a wide range of application including *early warning and detection; search, acquisition and track; missile guidance; communication; aerial mapping; navigation and altitude determination; countermeasures; fuzing; decoying; countermeasure initiation.*

Infrared can be used alone, as a completely passive system, with either active or passive radar, with optical systems, and with electronic systems to perform a wide variety of tasks. Of course, many of these developments are secret, and most of them are confidential.

Whether your interest relates to a current application of infrared, derived from the present State of the Art; or to future weapons systems, based on sound research and development; you are invited to investigate Avion's experience in this field. It dates back to 1949 . . . is supported by a staff of recognized physicists . . . and profits from a valuable accumulation of pertinent data. This scientific team, equipped with modern laboratory facilities, is well qualified to go to work *for you.*

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Switching Problems?...

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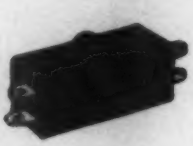
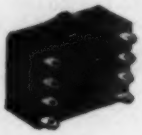
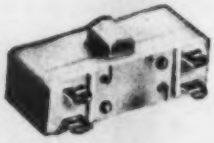
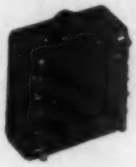
	MINIATURES			BASICS				MULTI-POLE		
										
DESIGNATION	S4			S1				D8		
CIRCUIT ARRANGEMENTS	SPST NC	SPST NO	SPDT	SPST NC	SPST NO	SPDT	SPDT 2 Ckt.	DPDT NC	DPDT NO	DPDT 4 Ckt.
AMPS-LIFE @ 125/250 V. AC	2.5A—150,000 CYLS.			10A—750,000				15A—500,000		
AMPS-LIFE @ 30 V. DC IND.	2.5A—50,000 CYLS.			10A—200,000				10A—500,000		
TEMPERATURE RANGE	—65° TO +200° F.*			—100° TO +375° F.*				—100° TO +375° F.*		
WEIGHT	.005 lbs.			10 GRAMS				15 GRAMS		
SIZE (INCHES)	27/32 X 23/64 X 0.260			1-1/4 X 1/2 X 1/2				7/8 X 1-1/4 X 1/2		
COMMENTS	Vibration/shock resistant, precise operation.			To 10,000,000 Ops. @ 1 Amp, 125 V. AC.				Simultaneous operation; poles may have different voltages.		

	MINIATURES			BASICS			MULTI-POLE		
									
DESIGNATION	S5			G3			K3		
CIRCUIT ARRANGEMENTS	SPST NC	SPST NO	SPDT	SPST NC	SPST NO	SPDT 2 Ckt.	TPST NO	TPST NC	TPDT 6 Ckt.
AMPS-LIFE @ 125/250 V. AC	2.5A—150,000			40A—100,000			15A—500,000		
AMPS-LIFE @ 30 V. DC IND.	2.5A—50,000			20A—100,000			10A—500,000		
TEMPERATURE RANGE	—65° TO +150° F.			—65° TO +300° F.*			—100° TO +275° F.*		
WEIGHT	1 OZ. APPROX.			20 GRAMS			30 GRAMS APPROX.		
SIZE (INCHES)	19/32 X 15/16 X 11/32			1-3/4 X 43/64 X 35/64			1-15/16 X 1-1/4 X .691		
COMMENTS	Sealed against dust, dirt, moisture, and corrosion.			Unusual space/capacity achievement; long life; can be ganged.			Reverses 3 ph. motors to 1 HP. Simultaneous make & break. Excellent life.		

*OTHER MODELS AVAILABLE IN TEMP. RANGES FROM —100° TO +400° F.

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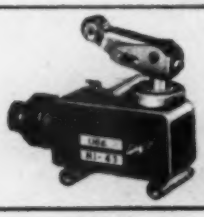	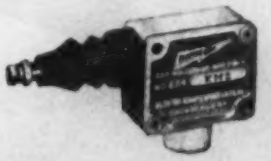
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DPDT	SPDT NO / SPDT 2 Ckt.
10A—200,000	10A—MIN 100,000
10A—200,000	
—100° TO +250° F.*	—67° TO +160° F.
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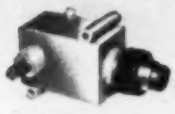	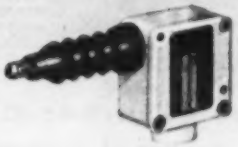
H10-7	E54-D
DPDT 4 Ckt.	DPDT 4 Ckt.
10—50,000	15A—500,000
15—50,000	10A—500,000
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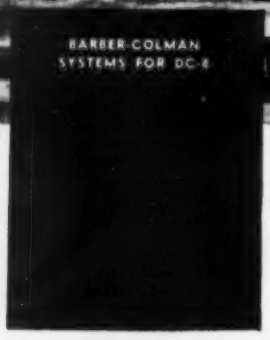

CONTROL BOX

ROTARY ACTUATOR

Douglas selects Barber-Colman temperature control systems for DC-8

As the DC-8 takes to the air, passengers and crew will enjoy a new standard of comfort aloft. Among its many refinements, this swift airliner will incorporate advanced Barber-Colman temperature control systems in both the main cabin and flight compartment. Powered by the craft's 400-cycle a-c supply, these control systems are the result of Douglas and Barber-Colman engineering teamwork to assure constantly accurate air conditioning under all flight conditions. For help on your control projects, consult the Barber-Colman engineering sales office nearest you: Los Angeles, Seattle, New York, Fort Worth, Baltimore, Montreal.

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in the flake. Johnson noise is a direct function of thermistor flake resistance, while detector output is primarily a function of its bias voltage and flake resistance. Taking the ratio of the two cancels out the two resistance terms making signal-to-noise ratio primarily a function of the maximum bias voltage that can be applied without excessive heating of the bolometer flake.

Another type of noise, called "current noise," resulting from bias current in the flake is relatively small compared to Johnson noise at normal bias levels. (Thermal detectors are mounted in evacuated containers to prevent generation of noise caused by air swishing back and forth across the flake under vibration.)

For photoconductor detectors, however, the current noise predominates except at very low bias levels. Thus the photoconductor cell's noise level is a function of the bias current amplitude in most applications.

Noise Equivalent Power

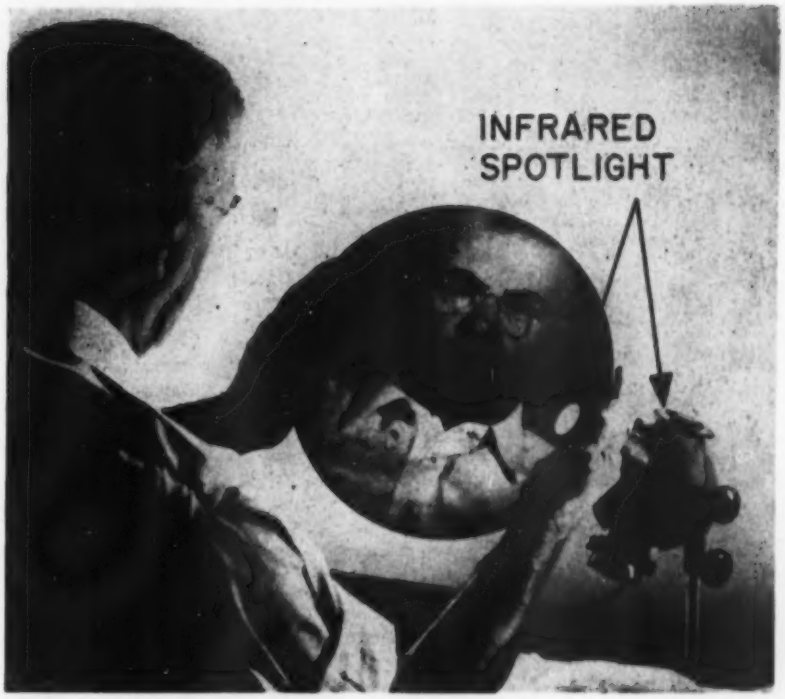
The random fluctuations in the intensity of IR energy received at the detector, resulting from target motion or variations in its temperature, make the detector's IR signal output relatively indistinguishable from its internally generated noise, until the former exceeds the noise level. For this reason infrared designers frequently define a detector's useful sensitivity both in terms of its response to infrared energy as well as its internal noise. Either of two terms are used: "noise equivalent power" (NEP), or "equivalent noise input" (ENI).

The NEP of a detector is the infrared power in watts which must impinge on a detector to generate a signal equal to its rms noise level over a reference bandwidth. For example, the NEP of a thermal detector is roughly 10^{-9} watts measured over a 60 cps. bandwidth, while that of a cooled lead sulphide cell is about 10^{-11} for a 1 cps. bandwidth.

Type of Detector

The reference bandwidth over which noise is measured to determine NEP depends upon the type of detector. In the thermal detector, where Johnson noise predominates, noise is measured over a bandwidth (in cps.) equal to $\frac{1}{t}$, where (t) is the detector's time constant. The infrared radiation impinging on the thermal detector is interrupted, or chopped, at a frequency below which detector response begins to fall off.

The fact that current noise predominates in photoconductor detectors, and that its power spectrum density varies inversely with frequency whereas Johnson noise power density is independent of frequency, leads to the use of a different method for specifying bandwidth of noise measurement in photoconductor detectors. In determining the NEP of a photoconductor cell, the upper and lower frequency limits of the noise measurement bandwidth are selected so as to give a ratio equal to the natural logarithm "e" (2.7). For example, the frequencies selected might be 27 and 10 cps., or 270 and 100 cps.



INFRARED lens reflects visible light but passes IR spot from infrared spotlight behind.

Speedier Response

Because the photoconductor has much speedier response than a thermal cell, a higher chopping frequency can be used, providing it does not exceed the frequency at which detector response begins to fall off.

In comparing the merit of two different infrared detectors in a particular portion of the spectrum, the one with the *lower* NEP has the *higher* overall useful sensitivity. Because this inverse relationship is psychologically confusing, another performance criteria is sometimes used, called "detectivity." The detectivity of a cell is the reciprocal of its NEP so that the higher a cell's detectivity figure, the better its performance. For instance, a cell with an NEP of 3.0×10^{-9} has a detectivity of 3.3×10^{8}.

Both the NEP and detectivity criteria were proposed by R. Clark Jones of Polaroid Corp., a leading authority in the infrared field.

Parabolic mirrors are used in many types of infrared detection, guidance and fire control systems to collect IR radiation and focus it on the detector. As in visible light optics, the energy focusing power of the mirror increases with the square of its diameter and inversely as the square of its focal length. Thus the figure of merit of an IR optical system frequently is expressed in the familiar terms of its "f" number.

The greater the focusing power of the mirror, the smaller the detector sensitive area that can be used which

FAMILIAR optical grinding techniques are used to shape infrared lenses.

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in turn provides faster response. Schmidt-type correcting plates are sometimes used between the mirror and IR source to enlarge the field of view over which sharp images can be obtained, thereby increasing the system's light gathering power.

In some detectors another lens of infrared transparent material is installed in the cell to provide additional focusing action beyond that provided by the parabolic mirror. The mirror itself is coated with a thin deposited film of gold or aluminum on its front surface to make it highly reflective over the entire infrared spectrum.

IRdomes

The infrared equivalent of a radome is usually called an IRdome, a contraction of InfraRed dome. It protects the infrared detector and optics from the elements and should be highly transparent to IR energy in that portion of the infrared spectrum in which it will be used, as well as being reasonably rugged and durable. No single material meets all of these requirements fully.

Servofrax, Servo Corporation of America's tradename for arsenic trisulphide, transmits approximately 70% of the infrared energy it receives over the range of about 1.5 to 10 microns and is relatively a low-cost material. Transmissability can be increased to around 90-95% over a narrow (2 micron) band by coating the material in a manner similar to the coating of optical lenses.

However, Servofrax can not be operated above approximately 150C for extended periods and its ability to withstand thermal shock is sometimes questioned, although a Servo Corp. spokesman says it can withstand 500C for 30 seconds without distortion or cracking.

Germanium has wideband transmissability from 2 to 15 microns, but it passes only about 50% of the infrared energy that strikes it and it is not suitable for high temperature use. Silicon can be used at higher temperatures, but its spectral response is more limited—about 1.5 to 9 microns. Fused silica (quartz), on the other hand, has good mechanical, thermal and transmission qualities (up to 95%), but it will not pass infrared radiation at wavelengths beyond about four microns, which greatly limits its usefulness.

Silver chloride has extremely wideband capability, transmitting 70-90% between 2 and 20 microns, but it is relatively soft, easily scratched, can not be ground or polished easily, and is a toxic material. Other materials, like sapphire, are expensive and difficult to obtain in large sizes.

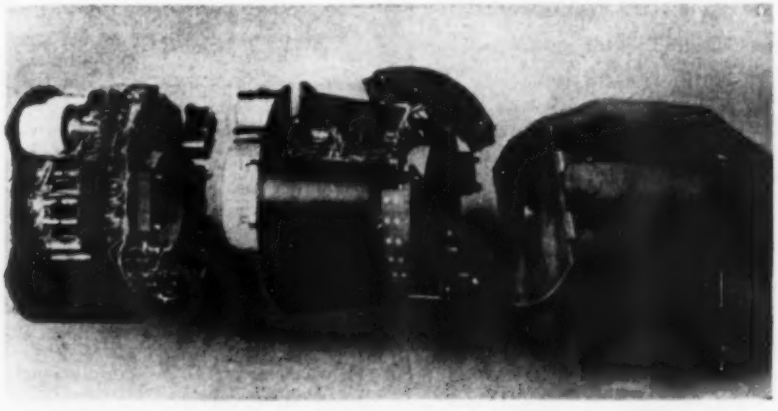
There are at least 20 different infrared optical materials available, each with its own mechanical/optical advantages and shortcomings. The material which an infrared system designer selects therefore depends upon the band and environment in which his system will operate.

Low-Noise Circuitry

In the design of electronic amplifiers for use with infrared detectors, every effort must be made to minimize amplifier-generated noise. Every resistor, every vacuum tube, every wire in the input circuitry is a potential source of noise which can obscure the low-level detector signal. At the relatively low detector signal frequencies that result from slow-scan modulation rates, it is necessary to provide extremely well regulated and filtered voltages for vacuum tube filaments, grids and plates.

Low-noise non-microphonic tubes and components must be used, particularly in an airborne environment. Careful attention to grounding and shielding is imperative. Between the detector and the amplifier, extremely high values of insulation resistance are required.

Wherever possible the pre-amplifier stage should be located close to the infrared detector. The small size of the



INFRARED guidance for air-to-air missile shows relative simplicity of an IR system.

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transistor suggests it could be built into the detector case to serve as a preamplifier, but transistors are notoriously noisy at low audio frequencies and present impedance-match problems.

Infrared circuitry is considerably less complex than radar circuitry as a rule. For example, the infrared-guided Sidewinder has only seven vacuum tubes whereas the radar-guided Hughes Falcon has several dozen. Some of the pulse amplification, automatic gain control and filter circuit techniques developed for radar can be applied in infrared circuit design. Broadly speaking, the level of detected signals is about the same for both radar and infrared.

The third, and concluding article in AVIATION WEEK's special report on aviation IR systems will describe some of the challenging areas which need research and development effort and some of the factors which are slowing progress in the infrared field.

Reprints Available

Reprints of Aviation Week's special report on infrared will be available in approximately six weeks. Single copies will be available free to subscribers upon request. Other copies will be billed at the following rates:

1-10 copies: 40 cents each.

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Over 100 copies: 20 cents each. Orders should be addressed to Aviation Week, 330 West 42nd St., New York 36, N. Y.

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Air Defense Computer Details Are Revealed

Los Angeles—Technical data on the transistorized TX-2, experimental digital computer system for the air defense program, was revealed at the Westec Joint Computer Conference here.

Construction of the TX-2 computer at the Massachusetts Institute of Technology's Lincoln Laboratory is the current step in the Lincoln program for the study and development of large scale digital computer systems, Lincoln's W. A. Clark revealed.

TX-2, combining high speed transistor circuits and a very large coincident-current tube-driven magnetic-core array, is designed to work efficiently in a system which has many input and output devices of different types.

Incorporating several new developments in circuits, memories, and logical organization, the TX-2 is projected as an important new member of the family of digital computers for real-time control and scientific applications.

Highlights of these new developments include:

- **Five mc. circuits** using the Philco surface barrier transistor are used in flip-flop and logical networks. Diodes are not used to implement logic and appear only in negligibly small quantities.
- **Several different memory** units, which use either vacuum-tube or transistor drive circuits, are used in the internal storage element of the TX-2. Total capacity of system is 70,000 words and expandable to 260,000 words.
- **Arithmetic and memory** units are logically organized into 9-bit sub-units independently and concurrently operated under program control.
- **Input-output system** provides for the concurrent programmed operation of many different devices in a mode called multiple-sequencing, an extension of the break point operation found in Sysear.

These features and other details were described in papers delivered by Lincoln's J. M. Frankovitch, H. P. Peterson, J. W. Forgie, R. L. Best, and H. K. Olsen.

Hughes Cutback

Hughes Aircraft Co. at Tucson, Ariz., is cutting back production to four days a week at its missile plant producing Falcon guided missiles and other electronics equipment for the Air Force.

The plant was awarded a $23 million contract last June for production of the missiles. Company spokesman said the cutback resulted from realignment of production, parts delivery and company delivery schedules.

New Amplifier Offers Radar Range Increase

New broad band, crossed-field microwave amplifier developed by Raytheon known as the amplitron promises to extend the range of CAA traffic control radars from 200 to 350 mi.

Raytheon said the amplitron is twice as efficient as any tube of comparable bandwidth and has 10 times the bandwidth of any tube of comparable power. It is one-quarter the size of other units having similar amplification factors and operates on less than half the voltage required by other microwave amplifiers. The amplitron is derived from the magnetron, from which stems the advantages in operating efficiency, simplicity of construction, size, weight and low operating voltages.

The amplitron uses crossed electric and magnetic fields, a re-entrant beam generated by a magnetron-type cathode and a non re-entrant broadband circuit matched at either end to external circuits. Input signal is amplified from 8 to 14 times.

A radar using the amplitron can be made to scan a sector without moving the antenna by varying the signal strength. It will also be able to shift frequency quickly to avoid a frequency jammed by enemy action or accidental interference. Application of the amplitron is expected to improve the efficiency of weapons systems using beam riding missiles.

The amplitron has bandwidths of 10% with efficiencies of 50%-70% throughout the band. Changes in anode current or voltage have little effect upon phase shift. Because of this there is little phase pushing and good reproduction of the input frequency. Because of low insertion loss, it is possible to duplex at the input rather than the output of the final rf amplifier.

Development of the tube was sponsored by Army Signal Corps Engineering Laboratories, Fort Monmouth, N. J.

FILTER CENTER

▶**Computer Courses**—Computation Laboratory of Wayne State University, Detroit, has scheduled several summer short-courses on computers, including:

- **Introduction to computers and their applications,** June 3-8.
- **Data processing in business and industry,** June 10-15.
- **Industrial and management computer applications,** Sept. 9-14.

University also has scheduled four-day conference on matrix computations for Sept. 3-6. Information on courses is available from A. W. Jacobson, Director, Computation Laboratory.

▶**3-D Radar**—A three-coordinate radar, which gives target range, azimuth and height has been developed by Air Force Cambridge Research Center's Electronics Research Directorate. New 3-D radar may find use in tactical air control and SAGE air defense systems.

▶**Electronics Blooms in Puerto Rico**—Forty-three U.S. companies have opened electrical and electronic manufacturing plants in Puerto Rico during past 10 years and their current annual production is running at about $14 million.

▶**New NBS Calibration Center**—National Bureau of Standards has started construction on its new $2 million Electronic Calibration Center at its Boulder, Colo., laboratories. New center will provide greatly expanded facilities for all frequencies now in general use.

Expansions, Changes In Avionics Industry

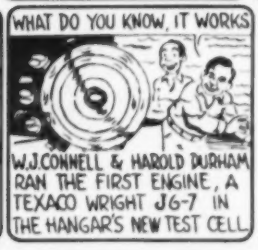
Beckman Instruments, Inc. will merge with Statham Laboratories, Inc., Los Angeles, manufacturer of transducers and instrumentation, subject to approval of shareholders. Beckman's sales for the current fiscal year are expected to top $40 million while those of Statham

SAC

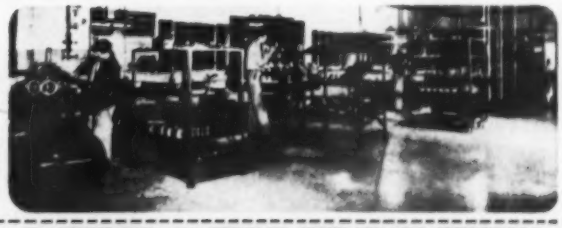
Silver Jubilee Newsreel

by JACK PATTON

LOOKS GREAT BY MOONLIGHT!
DOC, I'M SLEEPY
HANGAR 4 WAS BUILT IN 1935..... A REAL AERONAUTICAL TAJ MAHAL
DEUCES AND JOKER WILD!
ONE-EYED JACKS, TOO?
HAL HENNING HAD A THREE ROOM APARTMENT ON THE SECOND FLOOR.



The new 30,000 sq. ft. hangar—private flying's best—contained business aviation's leading engine overhaul shop (right).



Today, SAC's 100,000 sq. ft. Engine Division—which includes original Hangar 4—remains the home of America's finest overhauls for private owners and airlines (top). It's first, too, in the Jet Age under Air Force and Navy contracts (bottom). Private and airline jets are next!

1932 A QUARTER CENTURY OF LEADERSHIP 1957

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specialized application

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will run about $5 million. Beckman also announces plans for a $1.5 million expansion to triple production capacity of its Berkeley Division, Richmond, Calif.

Other recently announced expansions and changes within the avionics industry include:

• **Sperry Rand Corp.** will build $2 million facility in Clearwater, Fla., for research in microwave physics and development of advanced radar and missile instrumentation. New facility, to be managed by E. J. Venaglia, is expected to employ 150 engineers and technical personnel.

• **Bendix Aviation's Computer Division** has opened regional office in Chicago at 919 North Michigan Ave., headed by Robert C. Whiting, Midwestern regional manager.

• **Flight Research, Inc.,** Richmond, Va., manufacturer of photo data recording instrumentation and business aircraft controls, has formed new division to make single crystal silicon for use in semiconductors.

• **Elgin National Watch Co.** will close its American Microphone division plant at Pasadena, Calif., on Mar. 2, moving equipment and key personnel to Elgin, Ill., where production will be resumed. New warehousing facilities will be established in Burbank to serve West Coast customers.

• **Thiokol Chemical Corp., Inc.,** Trenton, N. J. has acquired National Electronics Laboratories, Inc., Washington, D. C. The new acquisition will operate as a wholly owned subsidiary under present name and management.

• **Texas Instruments, Inc.** has opened new Canadian semiconductor-components marketing office in Ottawa at 53 Queen St.

• **General Controls Co.,** Glendale, Calif. has merged with Production Instrument Co., Chicago, by purchasing all assets of the latter. General Controls makes automatic control systems; PIC makes mechanical and electric counting devices.

• **Synthane Corp.,** Oaks, Pa., fabricator of laminated thermosetting plastics, has moved its Southern California office to 1260 So. Central Ave., Glendale 4, Calif.

• **Radio Corp. of America** is establishing missile electronics engineering operation at Army guided missile test range, White Sands Proving Grounds, N. M. Leslie A. Skinner, former Army and Air Force missile expert, will be in charge.

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Frank W. Fink, V.P., Chief Engineer

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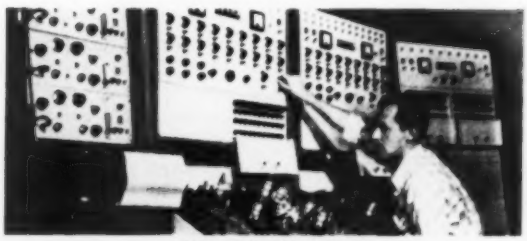
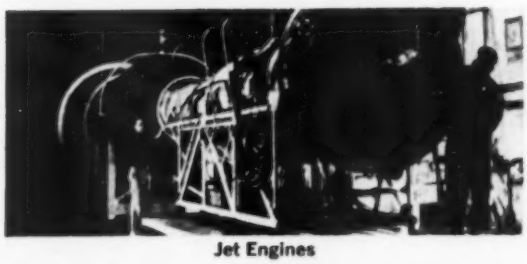


Electronics Systems



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SIZE – With 950 in the Engineering Division, Ryan is big enough to be diversified – small enough to be closely knit. You will get stimulating, broad experience – never feel "lost in the shuffle."

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World's Finest Aircraft Engines

INCREASED WINGSPAN, five feet greater than previous 560-A, marks new Aero Design 560-E Commander light twin business plane

Aero 560-E Profits from Longer Wing

By Craig Lewis

Oklahoma City—New high-performance Commander business plane and a revitalized sales and service program were unveiled here at Aero Design & Engineering Corp.'s recent national meeting of distributors. New sales and service plans are aimed at strengthening factory support of Aero Design's sales force in the field AVIATION WEEK was told.

Aero Design's new Commander 560-E is the end product of a program designed to increase the performance of the 560-A while retaining the use of normally aspirated engines. The company's engineers decided that the key was the higher aspect ratio wing, and they added 2½ feet to each wingtip. Span is now 49 ft. With the larger wing, power in each engine was increased by 20 hp. over the 560-A's 275 hp.

SPEED INCREASE to 222 mph., price decrease to $74,900, gives dealers good sales points.

New Wing

The 560-E represents a different approach to increased performance than that used with the Super 680. With the 680, Aero got its increase through added power from supercharged Lycoming 340 hp. engines, while the increase in the 560-E comes from the new wing. The 560-A, 560-E and 680 all have the same fuselage, and, with the exception of the longer 560-E wing, all have the same dimensions.

The new version of the 560 series raises the airplane's gross weight from 6,000 lb. to 6,500 lb., making it subject to Civil Air Regulations governing aircraft over 6,000 lb. To get its certificate, the 560-E had to be equipped with shutoff valves in the hydraulic and oil systems as required by CAA.

The 560-E has been type certificated and supersedes the 560-A on the Aero Design production line. Four of the new aircraft will be turned out by June, and production will be increased later in the year. The 560-E and the 680 will be produced together.

More Fuel

The 560-E has the heavier wheels and brakes used on the 680 and the 680 fuel system, increasing capacity from 156 gal. for the 560-A to 223 gal. for the 560-E.

Basic wing structure in the 560-E is about the same as that on the 560-A with the exception of the added length. The aspect ratio was increased from 8.02 to 9.45. Wing loading increased from 24.8 lb. sq. ft. to 25.2 lb. sq. ft.

With this more efficient wing, Aero uses the 295 hp. Lycoming high compression GO480-C1B6 engine in place of the 560-A's 275 hp. Lycoming GO480-D1A. The result is a 500 lb. increase in gross weight and a 400 lb. gain in payload.

Top speed for the 560-E is 222 mph. compared with 206 mph. for the 560-A. Cruise speed at 70% rated power at 10,000 ft. is increased from 200 mph. to 210 mph. Stall speed with gear and flaps down is decreased from 67 mph. to 66 mph.

Added fuel capacity will allow the 560-E to fly as far as 1,625 mi. at 10,000 ft. and 55% of rated power with a

Wanted:

Design and Development Engineers

MANY NEW aircraft—like the McDonnell Voodoo shown on the facing page—are equipped with Honeywell Autopilots, and other Honeywell aircraft control systems. And Honeywell's accelerated development programs call for many more such advanced systems to be produced.

Design teams now being formed offer exceptionally exciting careers to creative engineers capable of designing components and systems for—

- INERTIAL GUIDANCE
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- LIQUID MEASUREMENT SYSTEMS
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- DIGITAL COMPUTERS

At Honeywell you'll head up your own task group. Draftsmen, technicians, model makers and evaluation engineers essential to the project will look to you for technical instructions.

An engineering degree or its equivalent plus practical experience with related or similar equipment is required.

Consider these advantages

- Minneapolis, the city of lakes and parks, offers you metropolitan living in a suburban atmosphere. No commuting.
- Travel and moving expenses paid.
- First-rate salaries, insurance-pension systems, plant and technical facilities.
- Honeywell, leader in control systems, is a sound diversified growth company, continually expanding, that offers permanent opportunity to you.

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If you are interested in a career at Honeywell, call or send your résumé to Bruce D. Wood, Technical Director, Dept. TA1D, 1433 Stinson Boulevard N.E., Minneapolis 13, Minn.

MINNEAPOLIS **Honeywell**

AERONAUTICAL DIVISION

30 min. reserve. Similar range for the 560-A is 1,050 mi.

Distributors were enthusiastic to hear that Aero is listing a lower price for the 560-E than that charged for the 560-A. Basic 560-E will sell for $74,900. Basic price of the 560-A with high compression engines is $76,000, but equipped with heavier wheels and brakes, and the added fuel capacity of the 560-E, the 560-A would cost $81,000.

The more powerful 680 sells for $89,500.

In about six months, Aero will have conversion kits available for 560-A owners who want to switch to the 560-E model. Basic kit will be priced at slightly over $10,000, but with the new high compression engines and labor, the total conversion cost will be $26,660.

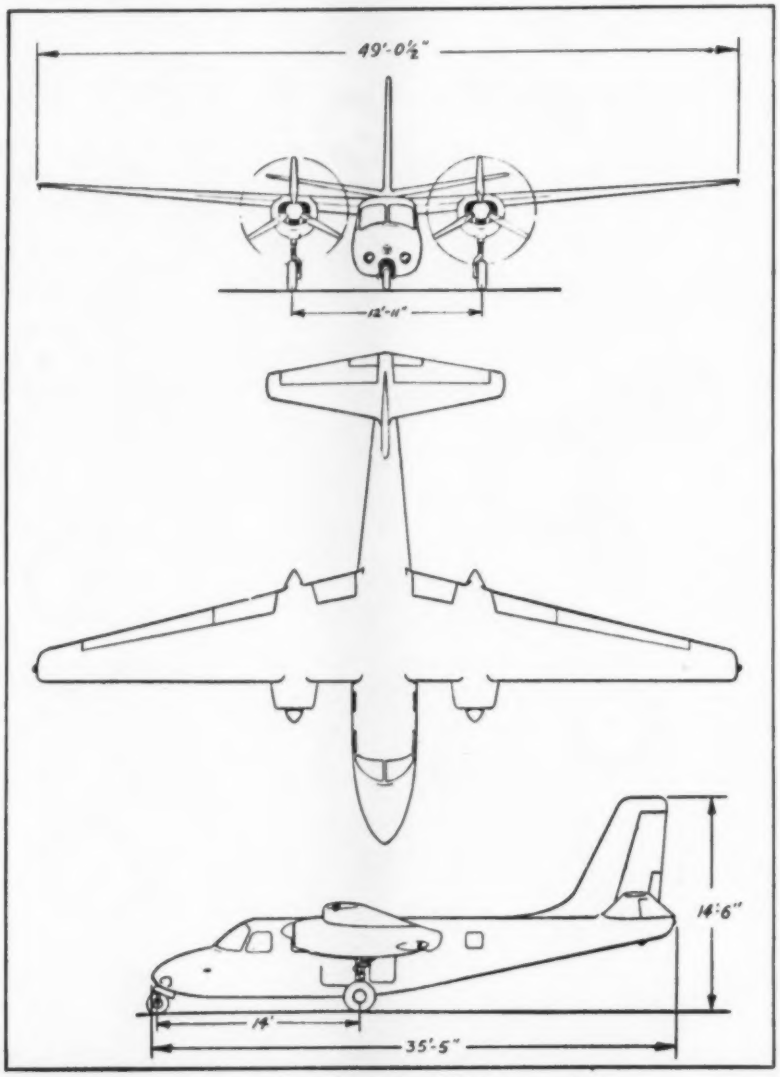
Extension of the wingtips provides added benefits in increased aileron efficiency. On the 560-A, the aileron came out to the wingtip. Now the tip of the aileron is 2¼ ft. from the end of the wing and is removed from the area of the wingtip loss.

New 560-E is the result of a year and a half long development program at Aero's research and development facility. The company's R&D program includes military work, and Aero Design is looking into the possibilities of getting more power for the present Commander series as well as the prospects of using turboprop and turbojet power for executive transports in the future.

Along with the 560-E, the company is introducing a number of radio packages ranging in price from $12,925 to $43,150.

Provisions are made for substitutions in the various packages to suit the particular needs of the customer.

To keep pace with its business growth, Aero Design retained Ernst and Ernst,



THREE-VIEW shows added length to wing of Aero 560-E Commander.

McDonnell's two top "Voodoo" fighters fly with Honeywell Autopilots. The classified F-101B (sister ship to the F-101A shown) has the new Honeywell MB-5 Autopilot, which does more for the pilot than any other flight control system ever designed. A primary feature of this autopilot is a universal coupler for automatic ground control intercept, for instrument landing, and fire control. The MB-5 is another example of Honeywell Aero leadership in high performance control systems.

AERONAUTICAL DIVISION, MINNEAPOLIS-HONEYWELL

Aero Commander Model 560-E

SPECIFICATIONS

High speed (rated power @ 10,000 ft.)	222 mph.
Cruising speed (70% METO power @ 10,000 ft.)	210 mph.
Stall speed (gear down, flaps 40° —power off	66 mph.
Gross weight	6,500 lb.
Empty weight	4,300 lb.
Useful load	2,200 lb.
Range (with 30 min. reserve @ 10,000 ft. @ 55% power)	1,625 mi.
Fuel capacity (usable)	223 gal.
Service ceiling (two engines)	22,500 ft.
Single engine ceiling (absolute)	8,000 ft.
Rate of climb (two engines S/L)	1,450 fpm.
Rate of climb (one engine S/L)	300 fpm.
Takeoff distance to clear 50 ft. obstacle S/L	1,452 ft.
Landing distance over 50 ft. obstacle S/L	1,500 ft.

All performance is based on full gross weight and standard atmospheric conditions, unless otherwise stated. All speeds guaranteed within plus or minus 3%. All climbs, ranges and altitudes guaranteed within plus or minus 8%.

management consultants, to help reorganize the company structure. The sales department is the first to be changed, and others are in the mill.

As the company's business grew, its sales division's organization remained at the level designed to cope with earlier, leaner years. The few individuals in positions of authority have been overloaded and thus unable to operate at peak efficiency.

Sales Organization

To cure this, Aero Design's sales efforts will be based on a pyramid type of organization with several new departments and positions created to spread authority and responsibility. R. J. White heads the whole operation as vice president and director of sales.

Under White are Carl Wootten, commercial sales manager, and Julian Prade, head of the new department of military sales. Also under White are the advertising and public relations department and the service department. There will be three regional service representatives traveling in the East, Midwest and West to help distributors.

Under Wootten in the commercial sales division will be six zone sales managers to bring Aero Design sales support to its distributors. Four of these zone managers have been assigned, and two more will be hired.

An expansion of the overseas sales program is underway and a European sales manager has been appointed to operate out of the Zurich office. A sales manager also will be named for Latin America.

Aero Design is currently laying out its advertising program for the coming months and plans to invest heavily in national and international advertising. The company plans a program of advertising and promotion in local areas aimed specifically at particular local industries. This approach, which will be supported on a cooperative basis by Aero and its distributors, is designed to give the distributor more specific help with his individual sales problems.

Military Sales

While primarily a commercial aircraft builder, Aero Design has sold Commanders to the military, and the company is increasing its military sales efforts with the establishment of a separate department for military sales.

Aero made its first military sale in 1952 when the Army bought the Commander, designated YL-26, for evaluation. Aero feels that it had the best aircraft in the competition, but lost the contract because of inadequate production facilities.

In 1955, the Air Force needed a small transport to fly President Eisenhower between the White House and his Gettysburg farm. The Commander was chosen, and the Air Force ordered 15 of them. The Army has bought five Commanders for executive use.

Distributors say that presidential use of the Commander has helped their sales efforts and has helped convince some reluctant businessmen that light twin transport operations are safe.

Aero Design hopes to sell more aircraft to the Air Force under a new concept of using such aircraft as the Commander under commercial operating practices. This would mean the Air Force would buy parts and service from Commander dealers just as business aircraft operators do. To help this sales pitch, Aero has retained Lytle Engineering Co. to write new handbooks and parts manuals, which will meet military standards, for all Commanders.

The company is solving another serious deficiency in its military sales efforts with the construction of new production facilities at its Bethany, Okla. headquarters. The new $1.5 million building, which is to be ready in September, will help relieve the military of any concern over Aero's production capacity if it wants to buy more of the company's aircraft.

Production is now between 18 to 20 aircraft a month at its present cramped facility at Bethany. When the new plant is opened, production can be more than doubled. So far, Aero has built more than 500 Commanders and has about a six month backlog.

The new plant will provide 126,000 sq. ft. of production space, including a 120 ft. by 360 ft. assembly line area. Production will be moved to the new building, which can be extended as more space is needed, and modification work will be done in Aero's present factory.

New Southwest Airmotive Base

Taking recognizable shape is Southwest Airmotive's new multi-million business aircraft center at Love Field, Dallas, Tex. Visible is the recently opened 11-acre concrete ramp surrounding the first completed hangar, which is the nucleus of a five-unit 880-ft. x 160-ft. building. In the foreground, right is the nearly completed Plane-O-Tel 400-ft. x 80-ft. storage hangar. To the right of the larger hangar will go a two-story terminal building and operations center to be completed by early 1958. The expanding business plane service center will cost $4 million on completion (AW Oct. 8, 1955, p. 105). For the fiscal year ending May 31, 1957, Southwest expects to gross $8 million.

Russians Claim Planes Keep Waterways Open

Moscow—Russians are claiming another aviation first: Use of planes to defrost frozen waterways and artificially extend the navigation season. The method entails aerial "dusting" of ice-covered waterways with powdered coal to absorb the sun's heat. The Russians claim that the blackened areas thaw 10 to 18 times faster than untreated ice.

At one location on the Irtysh River in Siberia, ice reportedly was melted in two days using the coal dust treatment, although average daily temperature was 21F.

The Russian Republic Ministry of Inland Shipping expects to use aircraft on a large scale to keep important waterways open for extended periods. It says that tests show that one plane can treat about 50 mi. of river in about 40 min.

The Russian claim for inventing this new use for aircraft does not say how long the technique has been used in that country. Bush operators in Canada have been utilizing the same principal for years to open frozen lakes to give them extra weeks of seaplane operation. One method used north of the U. S. border has been to coat the iced surfaces with black oil.

AT&T Proposes Test With Air-Ground Phones

An attempt to develop air-to-ground telephone service will be made soon by American Telephone & Telegraph Co., which will request Federal Communications Commission permission to use present 450 m.c. UHF frequency for a one-year test.

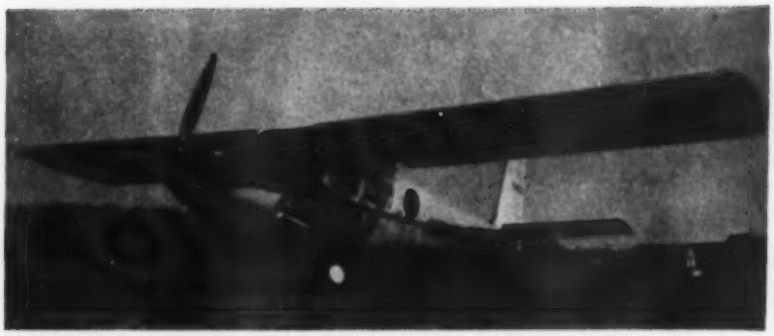
Approximately 20,000 aircraft may be equipped with air-ground phone service in 10 years, if necessary frequencies and ground facilities are established, according to industry observers.

It may take two or three years to obtain permanent frequencies. It is estimated that 40 channels may be needed to take care of demand in 10 years.

CAA Approves 170 Engine Conversion

Approval of installation of the 170-hp. Lycoming O340-A1A in the Cessna 170 replacing the standard 145-hp. Continental is approved by Civil Aeronautics Administration under supplemental type certificate SA3-13.

The conversion, designated Model 170A, was developed by Doyn Aircraft Co., Wichita, Kan., which offers conversion kits to 170 owners. Initial 170A has been delivered to Kenneth C. Butler, Hutchinson, Kan., president of the National Flying Farmers Assn.



THREE-BLADE HARTZELL propeller marks supercharged Helio Strato-Courier.

New High Altitude STOL Helio Courier Built for Aerial Photo

By Erwin J. Bulban

New York—Promising sales potential is shaping up for a new industrial version of the STOL Helio Courier, originally built as a "one-off" model to meet the requirements of a Mexican aerial photogrammetric firm for an economical high-altitude photo ship.

Basically a modified H-391 Courier, the new H-392 Strato-Courier features a supercharged Lycoming GSO480-A1A6 340-hp. engine replacing the 260-hp. unsupercharged Lycoming in the standard production Courier business plane. The new engine gives the Strato-Courier an altitude capability of 28,000-30,000 ft.

First Delivery

First airplane was delivered recently to Cia Aerofoto Mexicana, which proposed the modification. CAM, now operating approximately a dozen single- and twin-engine aircraft, mostly modified World War II surplus types, see the Strato-Courier as providing a reliable platform for aerial photo survey missions at a fraction of the cost of its current fleet. The older aircraft are not only becoming difficult to maintain because of increasing scarcity of parts, but are also expensive to operate.

There is a good possibility that if the Strato-Courier fulfills the requirements, the operator may replace more of his current older aircraft with additional H-392s, Lynn Bollinger, Helio president told Aviation Week.

Bollinger is optimistic that the company will receive additional orders for Strato-Courier. Currently he foresees a market for at least 25 airplanes in the aerial photo survey field in the near future and expects that demand will grow with the continued "exposure in the field" of the first airplane. He notes there are some 50 aerial survey firms doing this type of work all over the world, mainly with modified World War II equipment. Several aerial survey firms already have made inquiries about the airplane.

In addition to the Strato-Courier's new altitude capability, Bollinger said its slow-speed performance should also make it suitable for low-altitude pinpoint photo work. The Strato-Courier, extensively fitted with wide-span slots and flaps, has a speed range of from approximately 25 mph. to 200 mph., can clear a 50 ft. obstacle in about 300 ft. Rate of climb is over 1,600 fpm. and endurance is approximately four hours.

Modification of the CAM airplane includes stressing the cabin area to take loads of up to 1,000 lb., whereas the normal Courier is stressed for approximately 600 lb. A special floor was installed with a 24-in. cutout area to take installation of optically true glass for the camera installation and bracing for the photo equipment.

Except for a photographer's seat, the cabin behind the pilot's seat is clear area six feet long and 42-in. wide. This former rear seat-baggage compartment area will be fitted with some 450 lb. of camera gear.

Modified for Safety

The modifications were planned so that all stress problems meet CAR Part 03, Bollinger pointed out, although the plane is operating under a Restricted category Part 08 certificate. With the normal seats out, the 15-G seat belt fittings are braced to the structure. All modifications were made to retain the Courier's normal crash safety features.

Bollinger is not yet ready to talk specific price on future Strato-Couriers; it will probably be in the neighborhood of $45,000, depending on number of orders. As it now stands, future output hinges on blocks of orders of

N707BD
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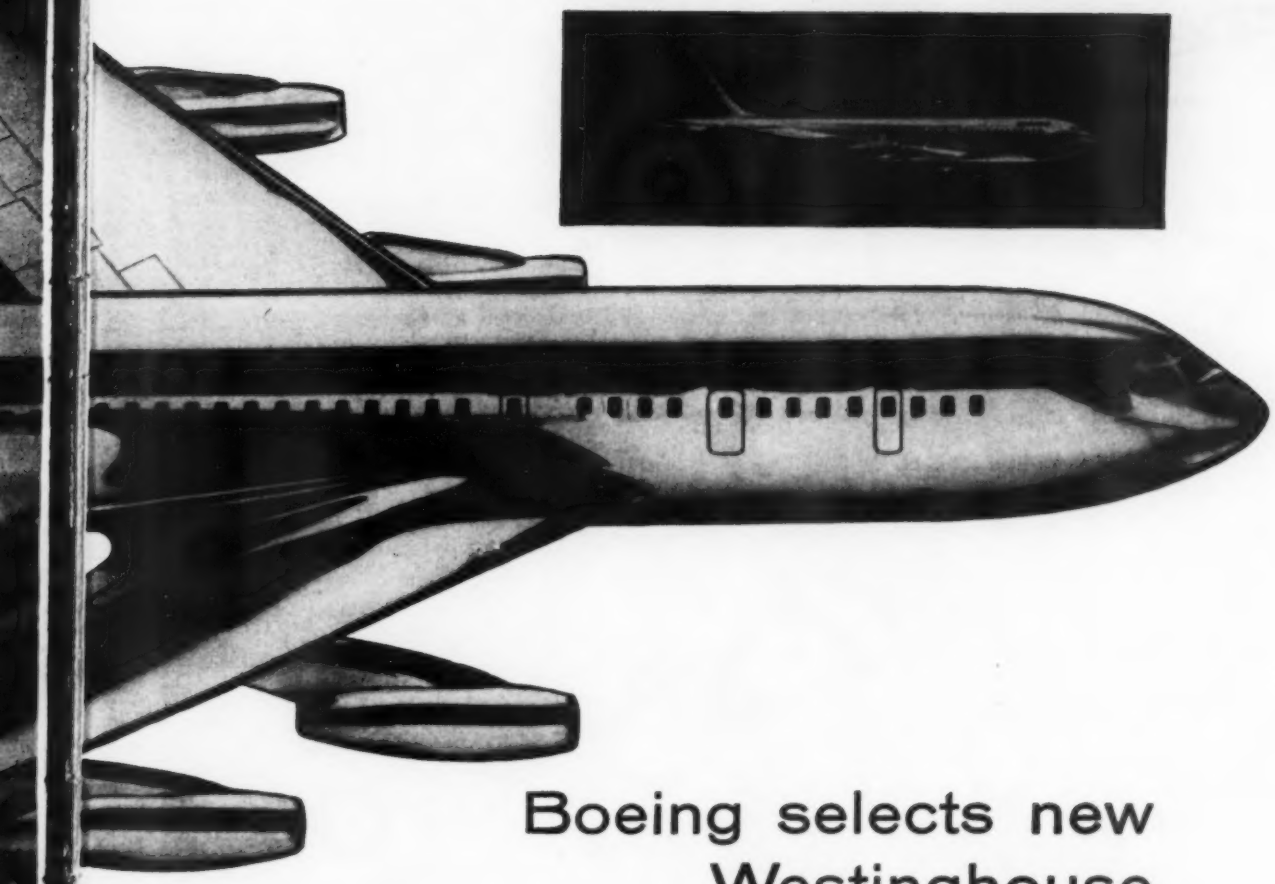

Boeing selects new Westinghouse electrical system for 707

AIRLINES ASSURED MOST ADVANCED PERFORMANCE BY NEW BRUSHLESS GENERATOR, NEW MAGAMP* REGULATOR, NEW STATIC CONTROL PANEL

Boeing engineers will achieve both *system reliability* and *reduced maintenance* for the new 707 Strato-Liner as a result of choosing integrated a-c systems developed by *Westinghouse*.

The rotating rectifier a-c generator eliminates commutators, brushes and collector rings. It does away with the troublesome maintenance problems that these components force on other systems. Excitation is self-contained in the generator—no vulnerable power cables between the generator and exciter. Static circuitry gives sealed-in accuracy, assures system reliability.

The systems are tailored to meet the requirements of the airlines using three or four generators rated 30 or 40 kva, and, of course, the systems have automatic protection.

Contact your Westinghouse sales engineer for complete information about this new integrated electrical system, or write: Westinghouse Electric Corporation, Aircraft Equipment Department, Lima, Ohio. J-03028

*Trade-Mark

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Another famous plane

PROVEN IN SERVICE

1926

At 9:02 a.m. on May 9, a trimotor Fokker is the first aircraft ever to fly over the North Pole. Only two days later the dirigible Norge spent two hours flying about the Pole.

Thirty-one years ago the Fokker's Polar flight was headline news — today it is but another memory of the "Good old days" of aviation. But even in 1926 Rockbestos wire and cable had earned a proven-in-service reputation.

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about 10 each for production runs. First production plane could be delivered in four months, with others following at one-a-month intervals, Bollinger states.

The Strato-Courier project was developed and built at Helio's research and development center at Norwood, Mass. The company's main production facility is at Pittsburg, Kan. The latter is now turning out H-391s on a two-a-month schedule. Approximately 48 H-391 Couriers are now in the field.

Thus far the airplane has been involved in two crashes, according to Bollinger, with no injuries suffered in either case. In one instance, the plane was taking off from a muddy field downwind, with 1,200-lb. aboard. The plane hit a tree and cartwheeled, landing on its back. The other crash involved a takeoff at dusk, downwind, the wingtip striking a knoll. Both occupants emerged unscratched, Bollinger said.

PRIVATE LINES

Joseph R. Salzman, 60, superintendent of maintenance for General Motors Air Transport Section since 1952, died after a three-week illness. A pilot since World War I, Salzman began his executive flying career in 1930.

Ninth annual Beech safety and efficiency clinic for owners of planes manufactured by the company begins Mar. 18 and will extend through September covering more than 30 locations throughout the U.S. Factory inspection teams will check planes brought into distributor bases; the dealers will notify Beech owners in their vicinity of their arrival. Last year the clinic checked 1,350 Beech Bonanzas, Twin-Bonanzas and 18s.

Medium-high frequency radio transmitter-receiver with transistorized power supply, contained in a ½-ATR case weighing less than 12 lb., is being marketed by Transval, Culver City, Calif. Transval Mk. IV has a frequency range from 2-10 mc., with six crystal controlled transmitting and six receiving channels for the entire range. Transmitter power output is approximately 35 watts into quarter wave antenna. Receiver audio output is 10 watts.

Cessna 310s ordered by the Air Force will be fitted with an Aircraft Radio Corp. Model 80F replacing the standard Lear navigation aid; an additional oxygen port will be added to provide five and a Wilcox glide slope indicator will be incorporated. Air Force is getting 80 Model 310s at a cost of over $5 million.

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Height comparison chart for model WP-3 P&H Welding Positioner

Mfr.	Minimum	Maximum	Range
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"B"	42"	66"	24"
"C"	40"	55"	15"

The chart on the left clearly shows how a typical P&H Welding Positioner has a 50% greater elevation—can turn larger weldments and lift them almost 1½ feet higher than competitive makes.

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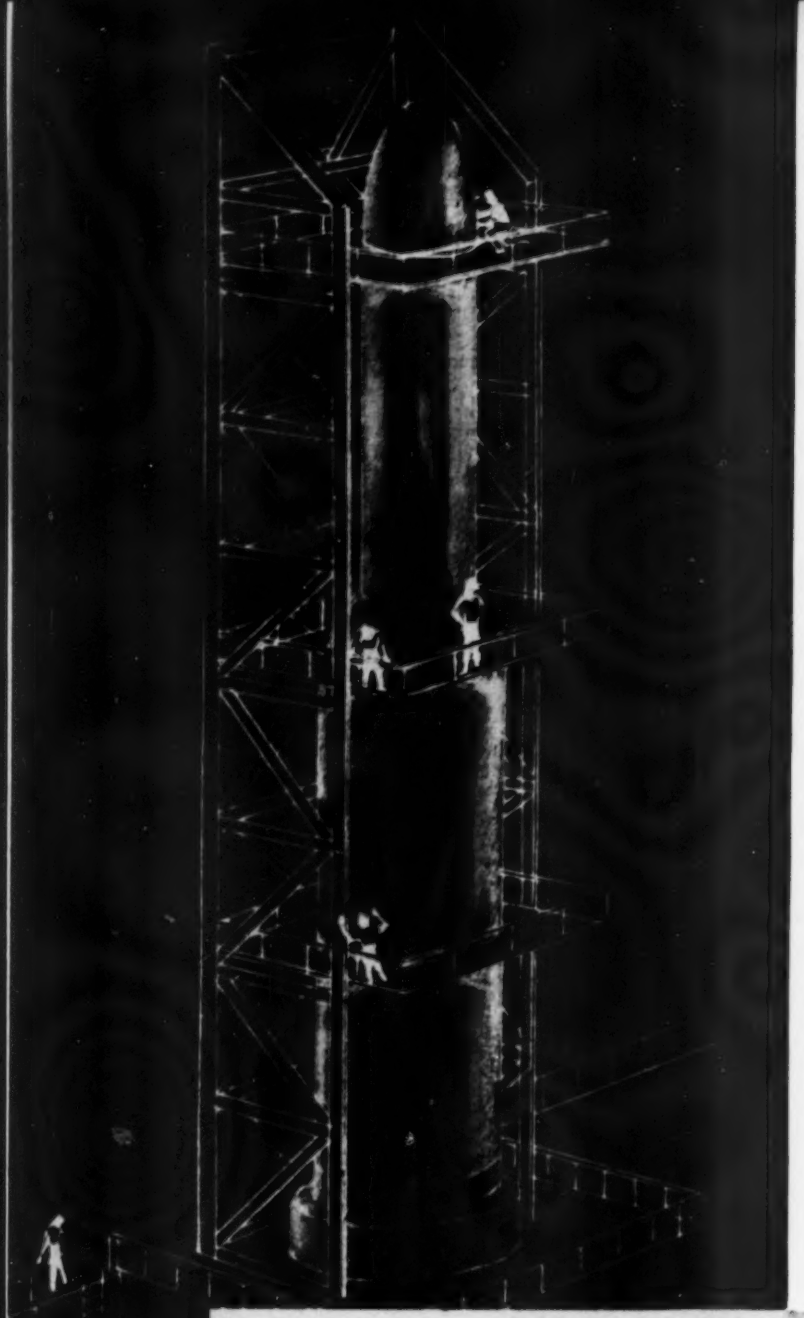

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WALLACE HAMILTON'S job is designing equipment for storing and transporting a missile and positioning it for flight. Mr. Hamilton is Chief Engineer of the Special Products Division and under his control over 100,000 annual man-hours of engineering talent are available for developing transtainers and launchers that use Cleveland Pneumatic's years of experience in designing and making heavy-duty equipment, shock absorbers and special mechanisms.

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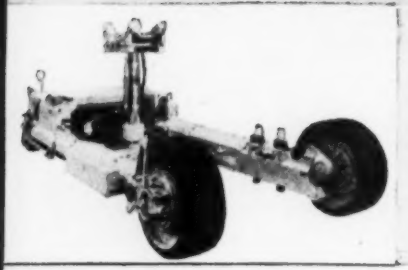
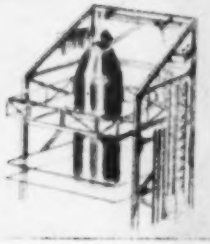


Mobile heavy-devices lift built by Cleveland Pneumatic to raise a heavy weapon 150" from ground and position it within $\frac{1}{32}$".



Servicing segment of missile work stand and tower as conceived by the project engineer of the Special Products Division.

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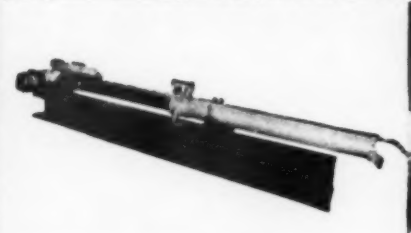


Large hydraulic actuator for supporting a fighter plane underneath the fuselage of a B-36 Bomber.

Artist's rendering shows a storing-transporting vehicle suitable for over-the-road or airborne movement. It was designed and developed by Cleveland Pneumatic's Special Products Division for a large missile manufacturer.

Complete test stand and launching facilities for an intercontinental missile can be designed, engineered, produced and erected by our Special Products Division.

A Progress Report on Faculty Salaries:

UP . . . But Not Nearly Enough

THE CHART on this page provides a report of the progress being made in solving a problem of crucial importance to every American. The problem is that of seeing that college and university faculty members get decent salaries.

This new chapter, which brings the story forward two years—from 1954, when it was last dealt with in this series of editorials, through 1956—has a decidedly cheering element. For in the last two years faculty salaries have made real headway.

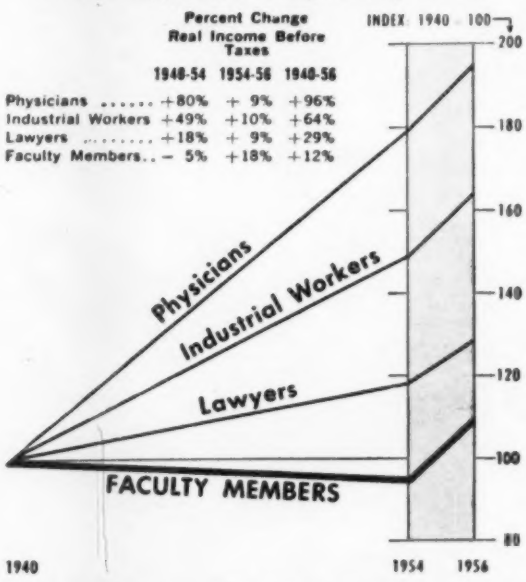
Two Years of Improvement

In 1954, in terms of what their salaries would buy, faculty members as a whole were actually worse off, by 5%, than they had been fourteen years earlier. As the chart shows, over the same period the real income of the average industrial worker had increased by almost half. And, in what it would buy, the income of the average physician, with professional training comparable to that of the average faculty member, had jumped by 80%.

In 1956, however, the average faculty salary would buy about 12% more of goods and services than it would in 1940. Relative to where they were two years before, faculty salaries showed a larger gain over the two years than those of any of the other groups whose salary progress is charted.

This movement of faculty salaries in the right direction has many contributing causes. The biggest single boost was given by the great Ford Foundation gift of half a billion dollars to our colleges, universities, and hospitals, almost half of which was ear-marked for faculty salary increases. Gifts from business firms have also

What is Happening to College Faculty Salaries



DATA: Council for Financial Aid to Education, U. S. Dept. of Commerce, U. S. Dept. of Labor, National Association of Education Research Dept., McGraw-Hill Dept. of Economics.

helped a lot. And so, in many cases, have stepped-up money-raising campaigns by alumni groups and cooperative regional and state groups of colleges.

Still a Long Way to Go

However, faculty salaries started their ascent from such a dismal depth that they still have a long, long way to go up before there is room for the comfortable conviction that they are fair, or even safe, from the standpoint of protecting the nation's vital interests. It still remains possible to find many shocking companion pieces for the following incident recently reported to a McGraw-Hill executive group, working on problems of financial aid to higher education, by the president of an illustrious small liberal arts college.

"The recruiting officer of one of our large industrial companies came to our campus a few weeks ago," the college president said, "and offered five of our seniors higher salaries to start working for that company when they are graduated next June than the salary received by any member of our faculty. And the seniors, of course, promptly went to their professors to seek advice on whether or not they should accept. It doesn't take much imagination to see what this sort of thing does to the morale of a faculty."

Senior Teachers Fare Badly

One of the more devastating things it does, of course, is to make the more experienced college and university faculty members receptive to the idea of going to greener pastures, currency-wise, in business and industry.

For these senior faculty members the financial pounding in the past 16 years has been even worse than the chart indicates. While the average real salary gain reported by the chart has been 12%, the average salary of a full professor still buys less than it did in 1940. This is because most of the salary increases have gone to beginning instructors, for whose services industry has been providing the sort of competition reported by the liberal arts college president.

And it creates this financial lackluster of posts as senior college faculty members right at the time their services are needed more than ever to handle the oncoming flood of college and university students. Between now and 1970 college and university enrollment is expected to double.

What is Needed Now

What is clearly needed is a continuation and intensification of the drive to increase their salaries to a point where college and university faculty members will be sharing somewhere near fully in the general prosperity of the nation. It could be counted good progress in this direction if over the next two years faculty salaries on the average were to go up another 12%, with most of the increase concentrated in the senior faculty ranks. And this can be made possible only through more outside contributions.

There is reason to be encouraged by the progress that has been made over the past two years in bailing college and university faculty members out of the terrible financial hole into which they were allowed to slide. But there is the most urgent occasion to keep at it and harder.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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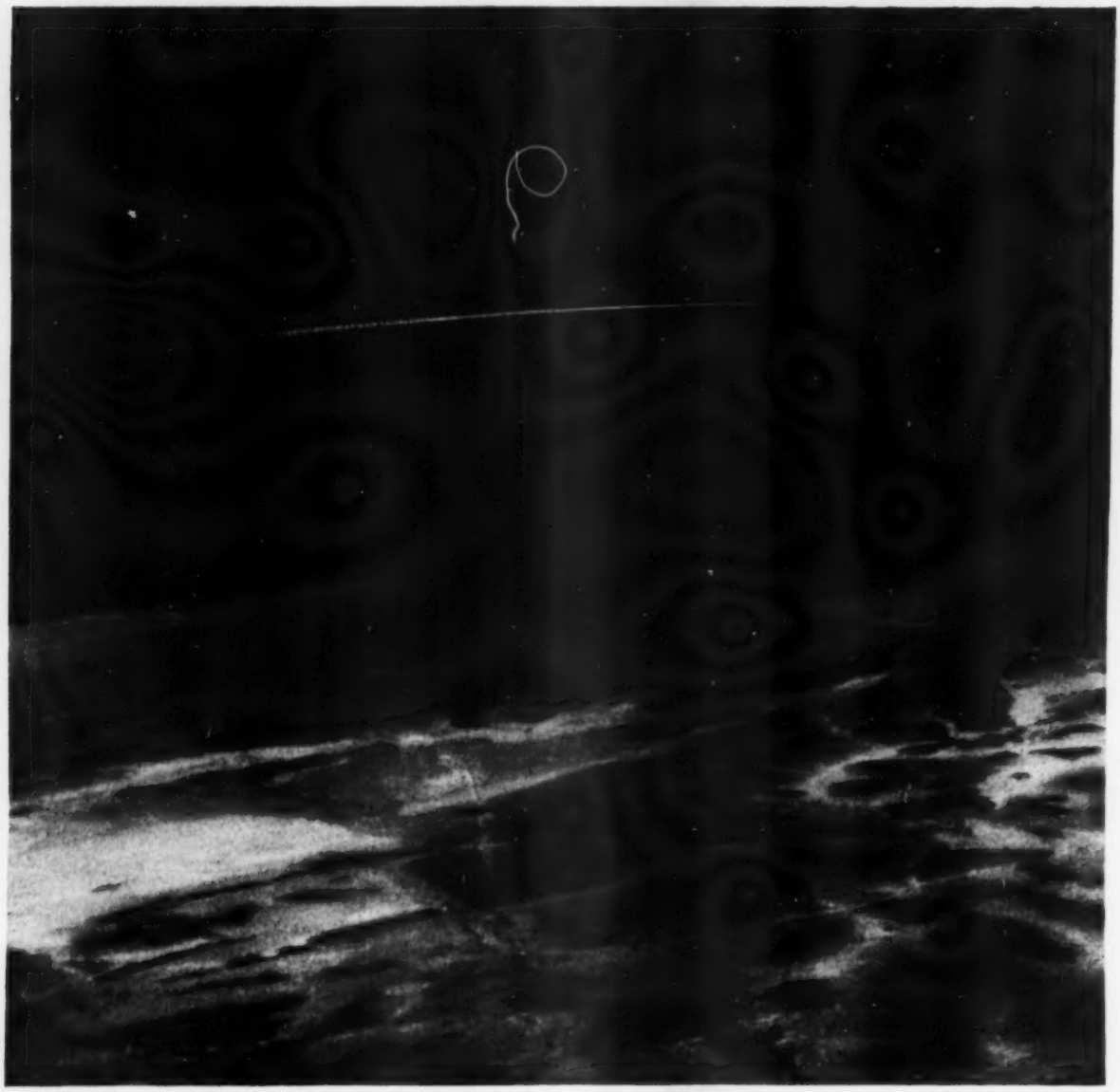

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British Accident Investigation Report:

Ground Control Faulty in Vulcan Crash

On October 26th, the Minister of Transport and Civil Aviation invited me to undertake an investigation into certain aspects of the accident to a Vulcan aircraft at London Airport. These points concerned the G.C.A. control under which the aircraft was landing when the accident occurred, and the terms of reference proposed were:

"To consider whether, on the occasion of the loss of Vulcan B.1.XA.897 on 1st October, 1956, there was any failure to operate correctly the Ground Controlled Approach at London Airport and, if so, to consider in what respects and whether, in the light of the circumstances of the accident, any changes are desirable either in the system or in its operation."

It was agreed that I should conduct the inquiry informally as if I were an inspector conducting a private investigation under the Accident Regulations. As the evidence previously given to the R.A.F. Court of Inquiry had been given on the understanding that it would not be used in any other inquiry or for any other purpose, I had to act independently and collect my own evidence. Whereas in the interest of fairness this was very reasonable, there were two unfortunate consequences. Firstly, the time taken for the investigation was increased. Secondly, and perhaps of more importance, the task of sifting the evidence was increased.

With the passage of time, the memories of some witnesses had understandably become vaguer. With some who had seen documents such as the Transcript of the G.C.A. recording as a result of previous investigations, it was difficult to determine whether they were remembering the event, what they had subsequently gleaned, or what they had told the R.A.F. Court.

However, I was supplied with certain factual appendices to the R.A.F. Court's Report, and these have been used. In addition, a list of witnesses, whose evidence was considered by the Court, was provided.

Bad Weather

An approach under bad weather conditions is a difficult flight operation; in my opinion, far more difficult than is normally recognized. Whatever aid is being used, whatever "coupler" is employed in the aircraft to interpret the information gleaned and translate it into aircraft motion, the process can be likened to a servo loop.

Each part, including the side spurs to the pilot, plays an important function in determining whether the approach is successful or not. It is necessary to discuss the loop in the light of my terms of reference. Perhaps I should have discussed it more fully before the start of the investigation.

To me, the whole loop is comprised in the ground controlled approach system, but I do not believe that was the view implied in the terms of reference. Many hold the view that the advantage of the G.C.A. system compared with other instrument approach systems is that by using a human computer (controller) on the ground, the elements outside the G.C.A. "rectangle" are not of great importance, provided the pilot makes a reasonable stab at carrying out the instructions received.

I cannot accept this view, without several reservations, such as a large break-off height. It follows that I also believe that approaches to a low altitude on G.C.A. cannot safely be made without each individual in the loop understanding what is required of him and what is happening under the particular circumstances, and having been properly trained for his particular task.

It is also well known that if the various elements or linkages in a "servo-loop" introduce delays, the system can become oscillatory. In G.C.A. such delays do occur and become of increasing importance as aircraft speeds increase. If the descent starts at the usual range from touchdown, it is obvious that with faster speeds of approach, there is less time for the controller to pass his instructions, and unless he increases his speed of patter, less information can be passed to the pilot, with the result that the control will not be as "tight" and larger errors become possible. Aircraft characteristics therefore affect the operation of the loop.

I have written the above since I believe my terms of reference were really meant to confine me to the G.C.A. rectangle in the diagram. I have had to go outside it, for the only certain fact we know is that the loop as a whole failed.

Real Issue

It will be seen later on that the real issue in this accident is which portion or portions contributed, and some of the main evidence suggesting that the G.C.A. rectangle was at fault concerns the improbability of the aircraft having carried out the flight path as given by the G.C.A. record. Nevertheless in this report, I have tried to restrict my activities to the main loop.

On 1st October, 1956, at around 10.00 hours GMT, the R.A.F. Vulcan, call-sign MPQK.11, flying to London Airport, approached the airfield under the usual A.T.C. directions under Radar Surveillance

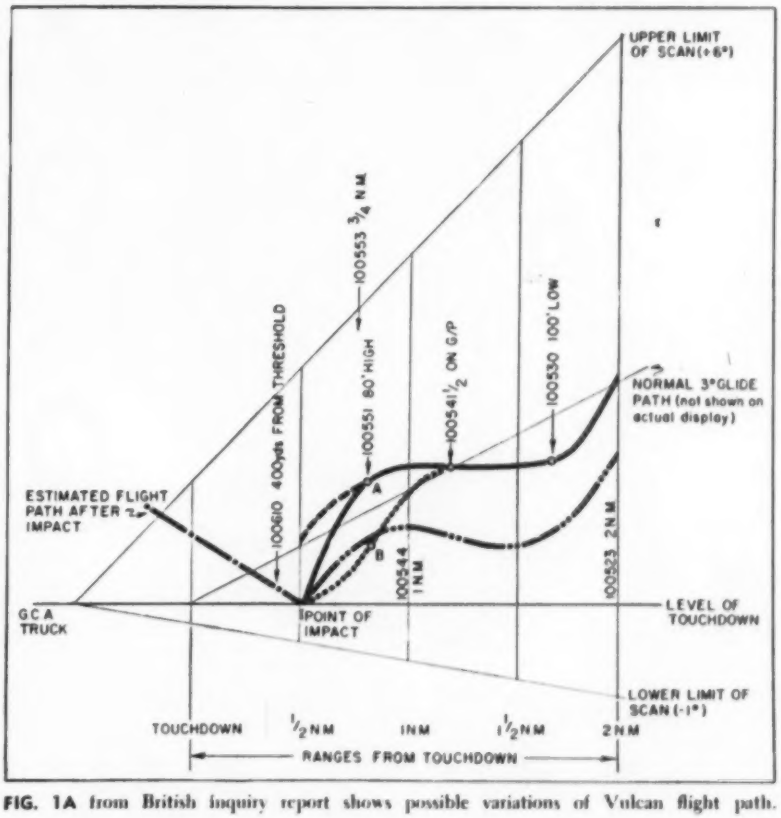

FIG. 1A from British inquiry report shows possible variations of Vulcan flight path.

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from the tower, the aircraft being handed over to G.C.A. for final approach when approximately six miles from touch-down. The landing runway in use was 10L, Channel B of G.C.A. Truck No. 124 being used for the talkdown. High intensity as well as runway lighting was fully switched on. The aircraft crashed on No. 4 Runway, after having struck the ground 2,000 ft. from the threshold of 10L Runway, at which time it suffered damage.

This report is therefore only concerned with events leading up to the initial impact.

The aircraft crew were:

Pilot: Squadron Leader D. R. Howard; Co-pilot: Air Marshal Sir Harry Broadhurst.

The G.C.A. crew on duty in Truck 124 were: Controller: Mr. J. Manning, G.C.A. talkdown controller, Rating—24th August, 1956; Elevation Tracker, Miss A. Maley, experience as a tracker 4¼ years, approximately 2,000 G.C.A. approaches; Technicians, Mr. H. V. Glen, Mr. P. Collins.

R/T communications throughout were very good. The initial let-downs and approach procedures needed care to be achieved, but the aircraft was successfully handed over to final approach, and consequently this report deals only with the last five miles of flight prior to initial impact.

Initial Impact

The Vulcan first touched the ground 1,988 ft. from the runway threshold, 250 ft. north of the extended center line, while still under G.C.A. assistance. At impact the aircraft was in a normal approach attitude, with nose up. The rate of descent was not excessive and probably was of the same order as for a normal landing, viz. about 180 ft./min. The airspeed was 140 to 145 knots, and there was no noticeable deceleration due to the impact.

The time of impact is of some importance but it has not been possible to determine the absolute time of this event or of any subsequent happenings, such as the final crash, to better than ±30 secs., which is not sufficiently precise to be of any value for subsequent analysis. One is therefore forced to try to time events relative to the G.C.A. talk-down and this is considered in more detail in a later section.

Engine power was increased just before impact, full power being reached afterwards. It is probable that the extra thrust was applied around 2 sec. prior to the impact.

The official weather conditions prevailing at London Airport at 10:07, i.e., approximately one minute after the impact, were: wind calm, heavy rain, visibility 1,100 yd., scattered low cloud down to 300 ft. (2/8), and 8th cloud at 700 ft. However, conditions were patchy. At the time of the accident there was mist and slight drizzle in the region of the runway threshold. Horizontal visibility looking outwards along the center line was about 800 yd. The aircraft was seen at ranges in excess of 1,000 yd.

Further back along the approach path, at approximately 1¼ n.mi. from touch-down, horizontal visibility at ground level was around 200 yd., but the aircraft was seen at a distance of about 400 yd. In this area it does not appear to have been raining heavily, observers speaking of mist and slight drizzle.

At the time of the accident, G.C.A. Truck 124 was fully validated with regard to the certificate of operation, Channel B last being flight tested on 11th September, 1956. Routine maintenance was up to date.

Immediately after the accident, various checks were made by M.T.C.A. personnel on the serviceability of the G.C.A. equipment. Within 15 min., a post-accident ground check was made by the G.C.A. crew following a standard London Airport procedure. The Telecommunications Officer examined the setting up and the calibration of the displays. Nothing was wrong.

I accept this evidence; moreover there is no other evidence which causes me to doubt it. Nevertheless there is room for human error in the setting up of the equipment. It would be preferable for the G.C.A. equipment in use at the time of any accident to be locked up immediately afterwards, and for the checks to be carried out by entirely independent personnel.

Post-Accident Check

A post-accident flight check in accordance with S.T.I. Part 2 was carried out during the afternoon—about 5 hours after the accident. Except for normal adjustments of operating controls, no alterations to equipment were made. The elevation component of the G.C.A. was found to be within the stipulated tolerance.

The azimuth component was found to be outside its permitted tolerance, the center line being deviated to the right at intermediate ranges (1.7 to 2.8 miles). This effect even of the magnitude reported by the flight check, although not in itself of any great consequence, nevertheless is to be deprecated. It would cause unnecessary instructions to be passed to the pilot, distracting the controller's attention.

However, the method of calibration employed is not very elegant, and subject to quite large observational errors. The data it provides are meager. Without implying that this contributed in any way in this accident, it is recommended that a check system based upon photographic recording of aircraft and aircraft echo should be adopted. D. of Tels. (M.T.C.A.) has been developing such a system and it should be employed as soon as possible. It would reduce the difficulties of keeping G.C.A. equipments within tolerance in the field.

Following the flight check, a full technical check of Channel B, Truck 124, was carried out by M. & I. Unit, Blackbushe, in accordance with hand-over procedure at Part 2, Chapter 1, S.T.I. This showed that the equipment was up to required standards with the following exceptions:

1. Precision Azimuth Aerial Synchronization. The tolerances for both maximum and minimum waveguide width were exceeded; this would limit the azimuth scan by not more than half a degree.
2. The elevation error warning light operated at minus 70 ft. instead of the prescribed 50 ft.
3. V.H.F. transmitter power output was below standard.

Deficiencies (1) and (3) are insignificant and did not materially affect performance of the G.C.A. In the case of (2), it appears that very little use is made of the warning light, but the error of 20 ft. is equivalent to ½ to 1 sec. in time with a rapidly descending aircraft and in some cases would be important. In view of the

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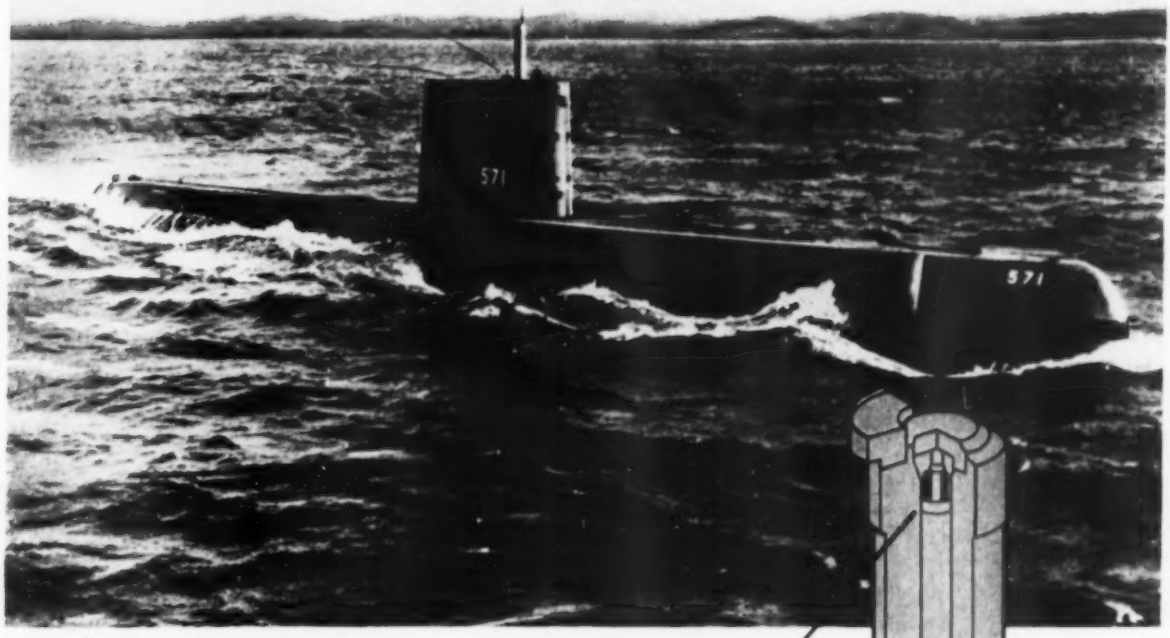

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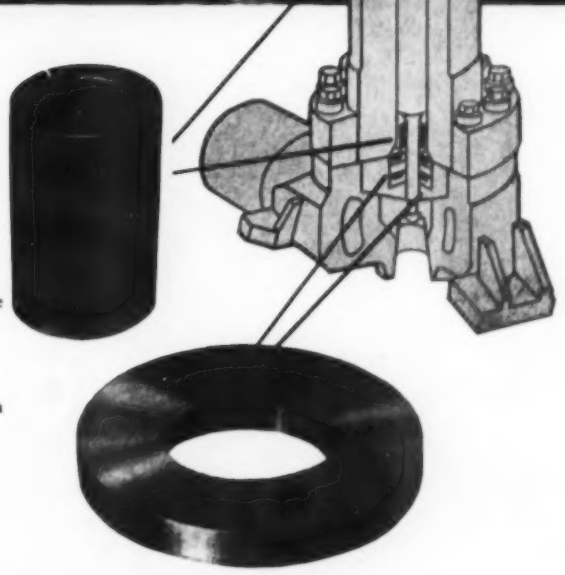

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complexity of the G.C.A. equipment, it is considered that these deficiencies are not a matter for any criticism. On the contrary, the G.C.A. crew appeared to be very conscientious and proud of their equipment and its performance.

In view of various stories which reached me and because of public interest, I have examined the history and record of G.C.A. Service at London Airport prior and subsequent to the accident. For the three preceding months no complaint, oral or written, can be traced.

After the accident, perhaps quite naturally, there is some evidence of uneasiness by Runway Controllers, and Air Traffic Control Officers. Truck 124 was examined on each occasion and at least two calibration flights were carried out.

No errors outside tolerance could be found. On some occasions, the reports of a low glide path were associated with aircraft flying on I.L.S. It must be remembered by both ground and air crew that G.C.A. and I.L.S. are allowed a tolerance in the glide angle of approximately .25° and .33° respectively.

Allowing for operational errors, there could easily be a difference of 50 ft. in the height of an aircraft at a nominal height of 150 ft. It is probable that this is the basis of the rumours about low glide paths on G.C.A. at London Airport.

I have therefore been unable to find any shred of reliable evidence suggestive of incorrect calibration or malfunctioning of the G.C.A. equipment over a period of several months.

The possibility of transient effects either due to mains voltage fluctuations or partial failure has been considered. None can be postulated that could have a bearing on the accident. Nothing unusual was noticed on any of the displays by any of the G.C.A. team.

It can be concluded with confidence that errors in setting up the displays, incorrect calibrations, or malfunctioning of any part of the equipment did not occur.

Unusual Effects

The question of whether any unusual effects could have played a part in causing the accident has been examined, both theoretically and by drawing on the experience of other G.C.A. users.

The larger wing area of the Vulcan compared with conventional aircraft of similar span was obviously the feature which might cause a surprise. If the lower wing surface is considered as a mirror, it is theoretically possible to obtain an echo at greater range than that of the aircraft scattered back from very rough ground under particular circumstances.

However, from geometrical considerations, this "ghost" echo could not have been the cause of the accident. On the other hand, when the aircraft is at a low altitude (less than 200 ft.), the energy reflected from the ground, particularly under wet conditions and if vertical objects such as trees are present, could substantially enhance the direct echo from the aircraft.

The effects of anomalous propagation caused by temperature inversion or water vapour, of aerial "squint," caused by a change in the frequency of the radiated energy, have been considered. They are too small to have caused trouble. As far as is known, no unusual effect has been noticed nor can be suggested, that would be of any value in explaining the cause of the accident.

One other effect should be mentioned, the possibility of obtaining additional echoes from the aircraft due to the side-lobes in the aerial polar diagrams. As G.C.A. is a scanning system, the echo from the main lobe would normally be present in much greater strength, and no confusion should arise.

Correct manipulation of the gain control would eliminate the unwanted echoes. It would be virtually impossible to track the aircraft in elevation on a side-lobe echo for any length of time without being aware of it. If the aircraft echo from the main lobe was masked by permanent echoes, then these should also show side-lobe echoes which would mask the side-lobe echo from the aircraft.

Talk-Down Record

A large part of the factual data is provided by the recording of the "talk-down patter" by the Controller. In this case, we are mainly concerned with elevation information, and the position of the aircraft as given by this patter and as it should have appeared on the elevation displays is shown in Fig. 1A (p. 111).

Unfortunately this record is not a precise record of where the controller thought the aircraft was, as the patter can be 2 or 3 sec. early or late; neither is it a record of where the G.C.A. equipment placed the aircraft. It is merely a record of the instructions passed to the pilot. In some cases it could be used to exonerate the functioning and operation of the G.C.A.; for example, when the Controller gives positive warning of danger. When such warning is not given, the G.C.A. must still be suspect.

This situation could be avoided. Indeed the explanation of this accident would not have been difficult to find if a photographic record of the displays had been available. Together with the talk-down record, it would be possible to analyse any approach. Suitable equipment exists; the running costs do not appear to be excessive. Assuming 6,000 runs per year at London Airport, the film per camera would cost around £500.

The cost could be reduced by recording only when the weather was worse than certain arbitrary limits. It is strongly recommended that if G.C.A. is to be used as a primary approach aid—as distinct from monitoring approaches being made on I.L.S. —photographic recording of the displays should be employed. It would be invaluable as a training aid and serve as a check upon the efficiency of the G.C.A. control team.

Returning to the talk-down record in the Vulcan accident, it should be noticed that the last message concerning height given by the Controller to the Pilot was "Going above the glide path—eighty feet high," at a range slightly larger than ¾ mile, corresponding to an altitude of 350 ft. No warning whatever was given to the Pilot that subsequently he was getting dangerously low. It can be concluded immediately that at least G.C.A. failed to give the protection expected from it. Also, having decided that no malfunctioning of the equipment or abnormal effects occurred it must follow

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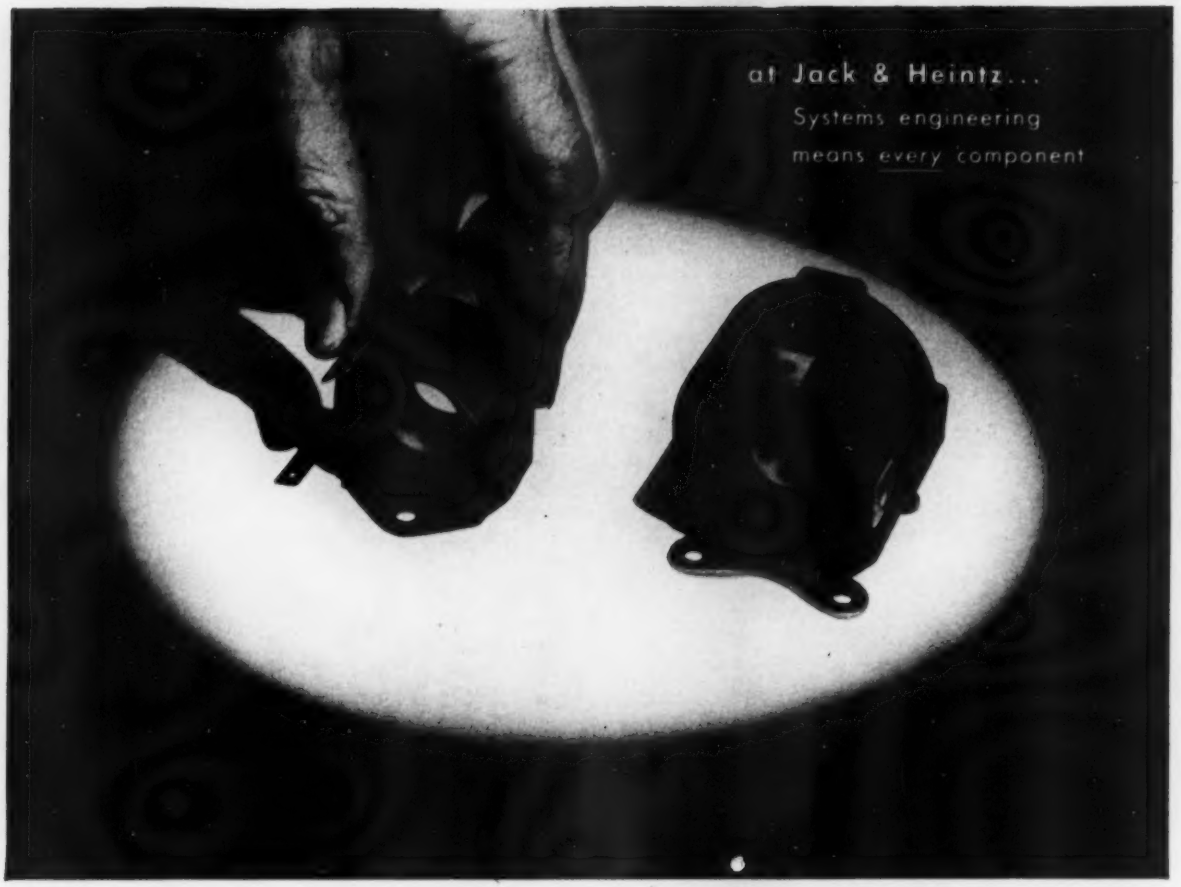

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that the explanation of the lack of warning must be that one or more of the human links in the chain failed in some manner.

Before searching for explanations, it is necessary to review the main evidence available about the later stages of the aircraft's flight:

(*a*) The two runway controllers were listening to the G.C.A. talk-down and have been able to fix the aircraft's position relative to the G.C.A. patter at two points, (i) when the aircraft was first seen, which occurred simultaneously with hearing the roar of the engines, at 100559±2, (ii) when the aircraft passed over their caravan at 100609. From these data, it can be deduced that (a) there was no range error of any consequence in the G.C.A. equipment, (*b*) that the last message given by the Controller ("400 yards from the runway") was about 6-8 seconds late.

(*b*) Five eye-witnesses saw the aircraft when it was between 1½ and 1¼ n.mi. from touch down and all agreed that it was much lower than civil aircraft normally are at that point, and they estimated its height as being around 100 ft.

Test of Witnesses

I was able to test these witnesses and am quite confident that the aircraft was anywhere between 200 and 400 ft. Three of these witnesses mentioned that there was an increase in power at this time, and whereas they might have been mistaken about the height, I see no reason to distrust them on this point.

(c) Pilot: Not unnaturally, the Pilot has only vague memories of the G.C.A. patter and the timing of events relative to it. He considers that the rate of descent oscillated around 500 ft./min. and that no large rates of descent (say 1,300 ft./min.) occurred. The airspeed at the start of the approach was 150 knots, slowing to 140 knots at the end. There were three changes of power during the approach, an increase being made after "100 ft. low." (This was probably the one noted by the eye-witnesses, sub-para. (*b*). Naturally his memories of the last few seconds prior to impact are not very precise as regards time. They are, however, as follows. He remembers being told he was 80 ft. high, after which he tried to regain the glide path by increasing speed by an adjustment of attitude. Somewhere about this time he asked the Co-pilot "Give me the lights," and was told "lights fine starboard." He had a glimpse of the lights, and did not like what he saw and started to take overshoot procedure. Almost simultaneously the Co-pilot told him "he was very low—pull up." A second or so later they touched the ground.

The rate of descent needed to fly an ideal 3° glide path at 150 knots is 800 ft./min. The average rate of descent for the Vulcan was 805 ft./min. based on the time it left 1,500 ft. as given by its altimeter, or 924 ft./min., based on the G.C.A. record (80 ft. high, at time 100421, range 4¼ n.mi). It is necessary to note this in order to interpret the pilot's observation that his rate of descent was never "gross in respect to 500 ft./min."

(*d*) Co-pilot: In general his story was the same as the Pilot's, in that there was nothing abnormal about the approach. He gave a description of what he saw of the

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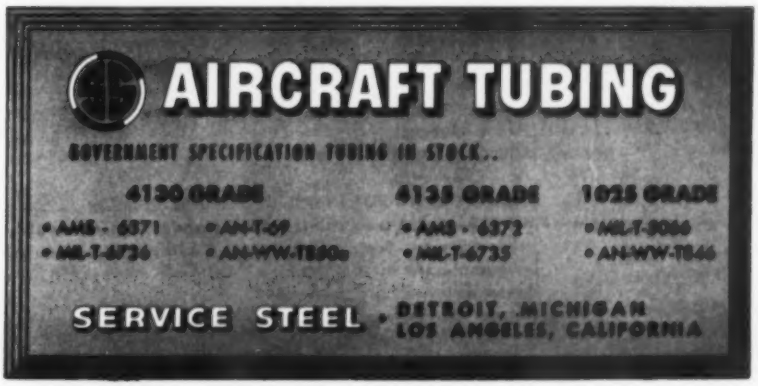

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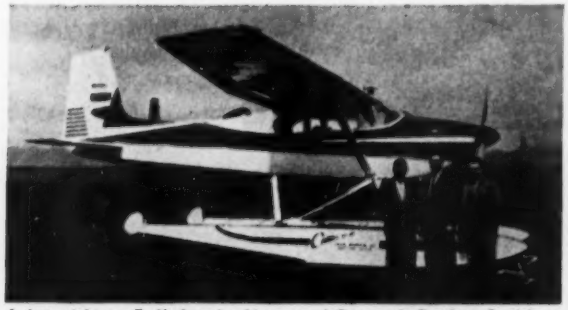

Left to right are F. H. Isaacks, Manager of Cameron's Southern Louisiana Division; Roy Davis, Domestic Sales Manager, and Herbert Allen, Vice President and General Manager of Cameron Iron Works, Inc.

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lighting system and what he reported to the pilot. This has been considered by Mr. E. S. Calvert, R.A.E., who is an expert on lighting and the transition problem. If it is assumed that the lights were visible for 600 yd., that the words spoken were in fact said, and that Calvert's ideas are correct, the conclusion can be drawn that the aircraft was not higher than 100 ft. for about 6 sec. prior to impact.

This depends upon a memory of time, and I am inclined to think that events could have happened much faster.

(e) Controller: The Controller is under the impression that the needle of the errormeter which indicates departure from the glide path did not go below zero after the point 80 ft. high (100551), that the "data-good" button was not operated, that the warning light did not come on. The echo on the azimuth display was of good strength until it disappeared at 400 yd. from the runway, possibly due to rain clutter. There was no rain clutter up to that point.

If this account is what actually happened, then there is the clear implication that the Elevation Tracker failed to track the aircraft echo correctly, at least during the final few seconds prior to impact.

(f) Tracker: The Tracker has been suffering from nervous debility, and consequently it could be claimed that her evidence is suspect. In addition, her evidence has to be interpreted very carefully, for she could hear what elevation errors were being given by the Controller, and on the day after the event, she saw the talk down transcript.

Tracker's Recollection

According to her, the echo was tracked continuously, until it was lost in clutter at a range a little smaller than ½ mi. There was little or no rain clutter. She noticed a very fast rate of descent at a range of about two miles, and drew the attention of the Controller to it. This had stuck in her mind because of the unusual speed of tracking required. Towards the finish of the approach, there was no similar rate of descent. This has puzzled her ever since and she cannot explain why it made no impression upon her, if in fact it did occur.

The Tracker does not have the glide path marked upon her display. A knowledge of height relative to the glide path can only be inferred relative to the permanent echoes or the limits of the elevation scan. If the aircraft signal is large, the permanent echoes would be unobtrusive. For these reasons, I have discarded the remainder of the Tracker's verbal evidence, since it is so obviously tainted with a knowledge of the transcript.

What is perhaps of greater significance is her account in the post-accident report, written 15 minutes after the accident and before it was known that G.C.A. might be implicated. "After a mile he seemed to settle normally." And again in a further report written a few hours later, "After two miles the aircraft descended further below the glide path and after corrections appeared to return to glide path approximately 1 mile. Approach then seemed normal until I switched off my light on completion of run."

The conclusion to be drawn from the Tracker's evidence is that after 1 mile the aircraft did not descend rapidly, and that the rate of descent was less than that which

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occurred at a range of around two miles.

(g) The Flight Path as given by the G.C.A. Record: If the aircraft descended from "80 ft. high," Point A in Fig. 1A, to ground at Point I, the average rate of descent must have been around 2,600 ft./min. Allowing for the check so that the aircraft can hit at 180 ft./min., the rate of descent must have reached 3,000 ft./min. In the check, starting at a height of 95 ft., the acceleration would amount to .8G, and 10 deg. of elevator would be required.

This is a possible, but very improbable maneuver. It is necessary to allow for the possible tolerances in position and time of Point A with reference Point I. Allowing all the factors to operate in the same direction, it is considered that the height at A might be 50 ft. lower and that the time taken from Point A to Point I might be increased by 4 sec. In this case, the rate of descent would have to reach a value of 2,000 ft./min. needing 6 deg. of elevator movement, 60 ft. of height and .5G in the check. There is no doubt that this would appear to be a reasonable maneuver.

The G.C.A. plot shows an increasing oscillation about the glide path. The whole flight path, excluding the last descent, can be achieved with mean elevator movements of ± 2 degrees (± 10 lb. force and ± .5 in. stick movement) and an associated excess G of less than 0.2. The final push at A could be achieved with an elevator movement of 2.5-3.0 degrees and a G approximately −0.25.

To see if a human error, either an error of judgment or an accidental slip, can be the basis for explaining what happened, it is necessary to postulate various theories and test them in turn.

The three persons involved are the Tracker, the Controller and the Pilot.

(a) Starting with the Tracker, it is possible that she tracked the aircraft incorrectly, over part or the whole of the approach. In fact, the Controller's evidence implies that the tracking was incorrect after Point A and he suggests that the error made indicated the dotted flight path in Fig. 1A. It could be argued that owing to the fast rate of descent, the Tracker lagged seriously behind, became confused and failed to operate the "data-good" button. This is possible, but I do not think it is probable for the following reasons:—

(i) The Tracker was very experienced. In two flights in which the Vulcan and the flight path were simulated by a Prince, another tracker of similar experience tracked the echo satisfactorily although it appeared to me that there might have been a time lag during the fast descents.

(ii) If the Controller's story is correct, the lag would have had to be of the order of 170 ft., which is much larger than can be accepted.

(iii) The Vulcan gives a good echo. All the evidence from other users suggests that the echoing area for the aircraft in approach attitude with undercarriage down is quite a bit larger than the head-on value. There was little or no rain clutter. The permanent echoes for the site are not excessive.

(iv) The Controller has stated in his post-accident report "Aircraft was not observed from 400 yd. to touchdown. This might have been due to rain clutter at that point. Response had been good up to that

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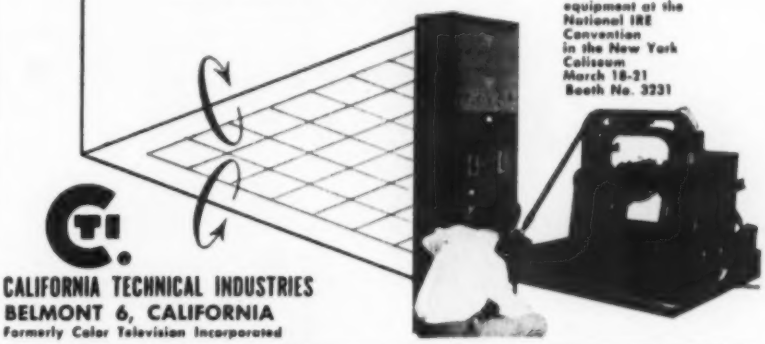

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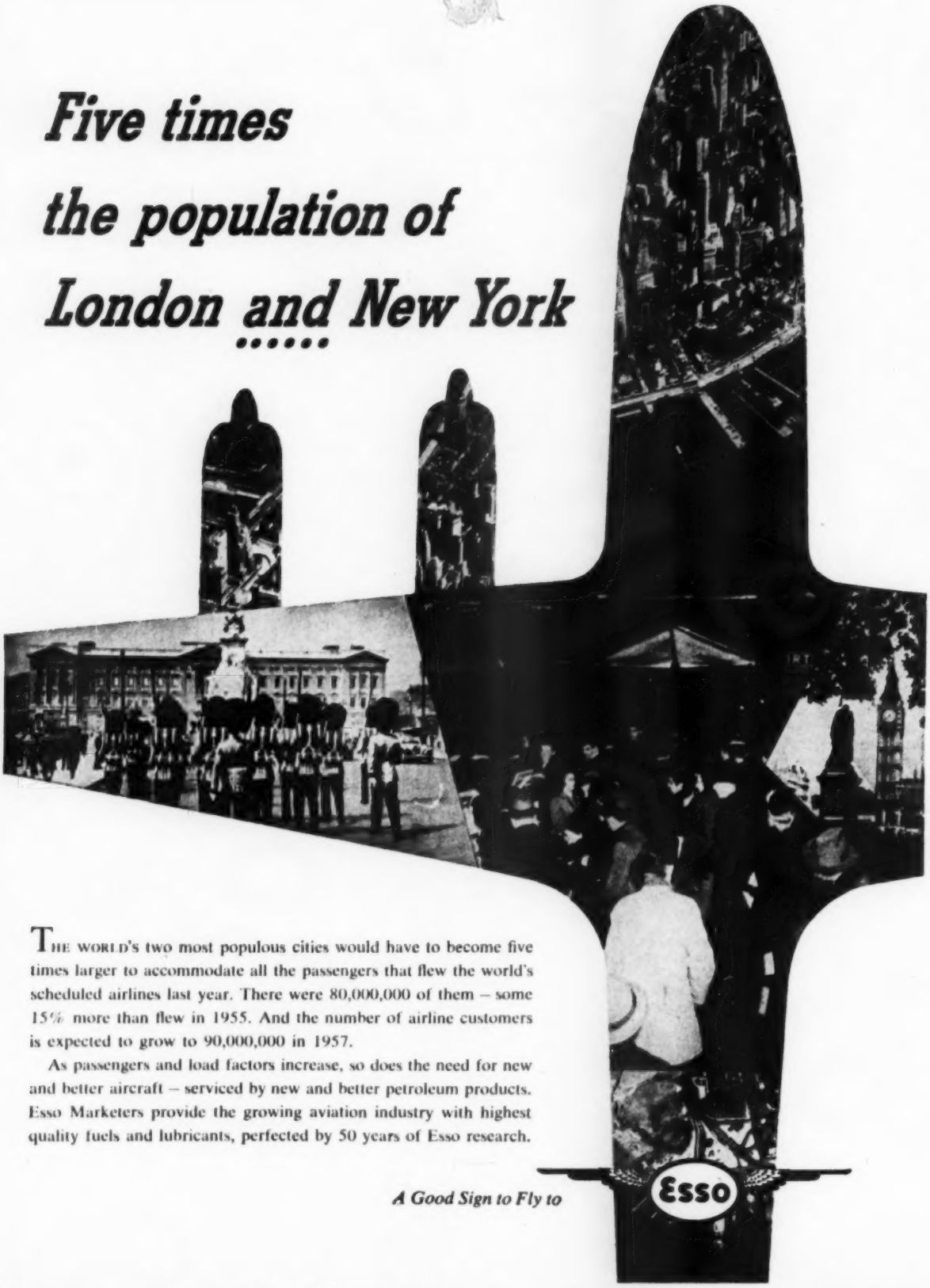

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point." The rain was very light, and the ratio of aircraft echo to rain echo increases as range decreases. Calculation shows that to obtain an echo from rain equivalent to that of a large aircraft the precipitation would have had to be in excess of 100 n.ms. per hour. This intensity occurs very rarely. An alternative explanation for the loss of the signal at 400 yd. is that the azimuth aerial had been servoed to a low angle as it would have been if the tracking had been roughly correct.

(*b*) It is possible to obtain side-lobe echoes, and the Tracker may have tracked on the upper one. For reasons given previously, I do not think this is likely to have happened for any length of time. It is possible that in the last stages prior to impact, if the gain was not correctly manipulated, the aircraft echo could become very large and an error in the direction of the echo might have occurred.

(*c*) It is possible to track the echo with the edge of the cursor, and it is not unknown for this to have been done. I have considered this possibility very seriously.

It can easily be shown that the lower edge of the cursor was not used on the 8-mile display. However, it could be postulated that when the aircraft did a fairly rapid rate of descent around 2 miles, the Tracker lagged behind and got the echo on to the lower edge, and in her concentration upon the tracking, mistakenly continued to do so. This would put the aircraft at a much lower altitude and would allow a reasonable rate of descent just prior to impact. The curve on Fig. 1A shows the flight path that would have resulted. It will be seen that it agrees with the Controller's statement about the behaviour of the error meter after Point A, and with the eye-witness accounts of the lowness of the aircraft. In spite of these agreements, I do not think this theory is very probable, for the following reasons:—

(*i*) It involves an error by the Tracker lasting over 25 sec.

(*ii*) It would necessitate the aircraft descending at between 2,400 and 3,600 ft./min. Although possible, it is aerodynamically most improbable, and involves the pilot in committing a serious flight error over a period of 9 to 12 sec.

(*iii*) It brings the aircraft down to the break-off height at a range of 1¼ n.mi.

(*iv*) There would have been a discrepancy of 220 ft. between the altimeter height and the G.C.A. height derived from range. The pilot should have noticed this, but in fact was satisfied that there was reasonable agreement.

I have been unable to postulate any other feasible tracking errors.

(*d*) Turning to the errors that the Controller could have made, it is necessary to examine the hypothesis that he erred in the last elevation message and should have said "Going *below* the glide path, 80 ft. *low*." Instead of being at Point A, the aircraft would have been at Point B.

It is immediately obvious that the resulting flight path agrees with the Tracker's description, given only a few minutes after the approach, that "after one mile he seemed to settle normally." The rates of descent involved, 1,300 to 1,400 ft./min., are entirely possible in view of the average of 920 ft./min. for the approach as a whole. The only evidence that must be discarded

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Here members of the Electronics Division discuss systems radar problems related to measurement of missile trajectories. Left to right: K. T. Larkin, radar and command guidance; Dr. S. B. Batdorf, head of the Electronics Division, Dr. H. N. Leifer (standing), solid state; Dr. R. J. Burke, telemetering; S. Janken, product engineering.

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is that by the Controller about the movement of the error meter after his last elevation message. Only one person is involved in making the error. The evidence of the Co-pilot regarding the lights fits, although for reasons given earlier, not too much weight should be given to this.

In spite of the agreement with circumstantial evidence, this theory is not probable for the following reasons.

(i) A slip of the tongue is quite feasible, but this would mean that the Controller would be aware that the aircraft was low, and would certainly have given further corrections. The theory is only tenable if an inversion in thought as well as speech occurred. This type of human error is extremely rare.

(ii) It also involves the assumption that the Controller did not look at the error meter after the message. If this is so, a simpler solution, not involving a double error, is possible.

(e) The simpler solution is that the Tracker followed the aircraft echo more or less accurately, but that the Controller did not pay sufficient attention to the error-meter after the point "80 ft. high."

Controller's Patter

It can be seen from the transcript at the talk-down that after this point, the Controller's patter was concerned with range and corrections in azimuth. This shows that he was mainly looking at the azimuth display. It is generally recognized that it is difficult to watch both error-meter and display at the same time.

On this basis, it is possible to formulate a theory which appears to be a reasonable compromise with the evidence. After "100 ft. low" (100530) to "on the glide path" (100541½) the rate of descent appears to have been low, of the order of 150 ft./min., and this was noticed by eye-witnesses. Afterwards to 100551 it appears to have increased to at least 300 ft./min. It is therefore possible that the Tracker may have erred slightly on the high side in bisecting the echo. If the latter limit for the time of impact, 100601, is taken, the tolerances given in para. 9 (g) are possible, and the resulting rate of descent, although high, is acceptable. During the descent, it is not unreasonable to postulate that the Tracker lagged behind by 50 ft., especially if a fairly large echo was being used. The error-meter would have reached zero about 5 to 6 sec. prior to impact and the warning light would have come on about 2 sec. before impact. If the Tracker switched her light off when she lost the echo just after half a mile, it means postulating that the Controller did not observe the meter for a period of 7 to 8 sec. This is not unreasonable as he was busy with azimuthal corrections and his last two elevation messages had been spaced 10 sec. apart. If he glanced at the meter during the first 5 sec. he would be left with the impression that the aircraft was returning to the glide-path. The warning light came on too late to be of any value.

This is as near as I have been able to get to any reasonable explanation of what happened. It would mean that the Controller made an error of judgment, preferring to concentrate on azimuthal instead of elevation information, not expecting any sudden descent to occur at such a late stage in the approach.

Whatever the reason for the error in the G.C.A. truck, about one matter there can be little doubt. The last elevation message was given by the Controller when he thought the aircraft was at a point more than three quarters of a mile from touchdown, at a height in excess of 300 ft., under poor weather conditions. This is so, irrespective of the condition of the G.C.A. equipment or its setting up. He continued talking for a further 20 sec. and it is curious no further height information was given.

The Controller has explained that he thought the aircraft was above or on the glide path. Even so, this information should have been given to the Pilot so that he could judge his position and his rate of descent, especially as he was approaching the difficult transition of going visual.

In addition, the aircraft had oscillated continuously about the glide path and had shown little signs of reaching a stable descent. The curious bit of patter "You're quite clear to land on this approach," coming during the closing seconds, even though it had been given earlier at the correct time, was of no value to the Pilot in flying his aircraft. The time should have been spent in giving elevation data.

I am unable to postulate a really satisfactory theory that would place the aircraft at a lower altitude than that given by the Controller near the finish of the approach, to allow for a less steep descent prior to impact. But if any such explanation could be given, it follows that the aircraft must have lost that height elsewhere during the approach. The only way of avoiding the conclusion that no steep descent occurred at any time is to assume that the G.C.A. height record is complete nonsense. That I am not prepared to accept.

Record Accepted

I therefore accept the G.C.A. record as being correct, subject to the normal tracking, observational and timing errors. In elevation, it is typical of a servo-mechanism out of control. It follows that I accept the existence of a steep dive after the point "80 ft. high," since it provides the only rational explanation of the accident that I have been able to find. I admit that this conclusion does not follow from the majority of the verbal evidence given to me, but this evidence is itself inconsistent.

In considering the entire operation, it is necessary to examine what happened in azimuth. The aircraft crossed the centre line roughly at 4¼ mi. and was always north of it, in spite of three 5-deg. corrections. As a result the Controller gave much more attention to azimuth than is normal, and this left him less time for giving elevation and range information.

Although the Controller did not consider that he was under stress, at least he was being hurried more than he thought. A small sample of talkdowns by other controllers chosen at random show a spread in words spoken per minute of 82 to 126, with an average of 110. On this occasion, the Controller averaged 146, obviously reacting to the increased ground speed.

It is not possible to deduce from the evidence what actually happened in the G.C.A. truck after the point "80 ft. high." In this matter I shall have to base my decision entirely upon my judgment of what I have seen and know of the witnesses and upon

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scraps of evidence not mentioned in this report. I believe that the explanation given above cannot be far wrong—that is, that in the closing few seconds the Controller was not paying sufficient attention to the elevation situation.

The question must be asked whether prompt action by the G.C.A. crew could have warned the Pilot in time to have averted the accident. It is difficult to answer this in exact terms, since the actual rates of descent and time available for action are not accurately known. However, to check the aircraft with a rate of descent of 2,000 ft./min. with 6 deg. elevation, no power applied, so that the wheels would graze, requires 3.5 sec. with a loss of height of 65 ft. For 2,500 ft./min. 4.0 sec. and 95 ft. are necessary. Allowing 20 ft. clearance above the ground, and only 1½ sec. for the transmission of the warning message and initiation of action on the part of the Pilot, the warning would have had to be given 5.5 to 6 sec. prior to the lowest point of the flight path. The simultaneous application of full power would not alter these times significantly. The permissible tracking error could add 0.5 sec.

If, therefore, a dangerous situation had been recognized by both Controller and Pilot, and very prompt action taken, the time necessary to avert the crash would have been of the order of 6 sec. *The vital period was therefore the 3 to 5 sec. after the "80 ft. high" point*, and the questions whether the Controller observed the errormeter during the last few seconds, and whether the warning light came on, etc., are largely academic.

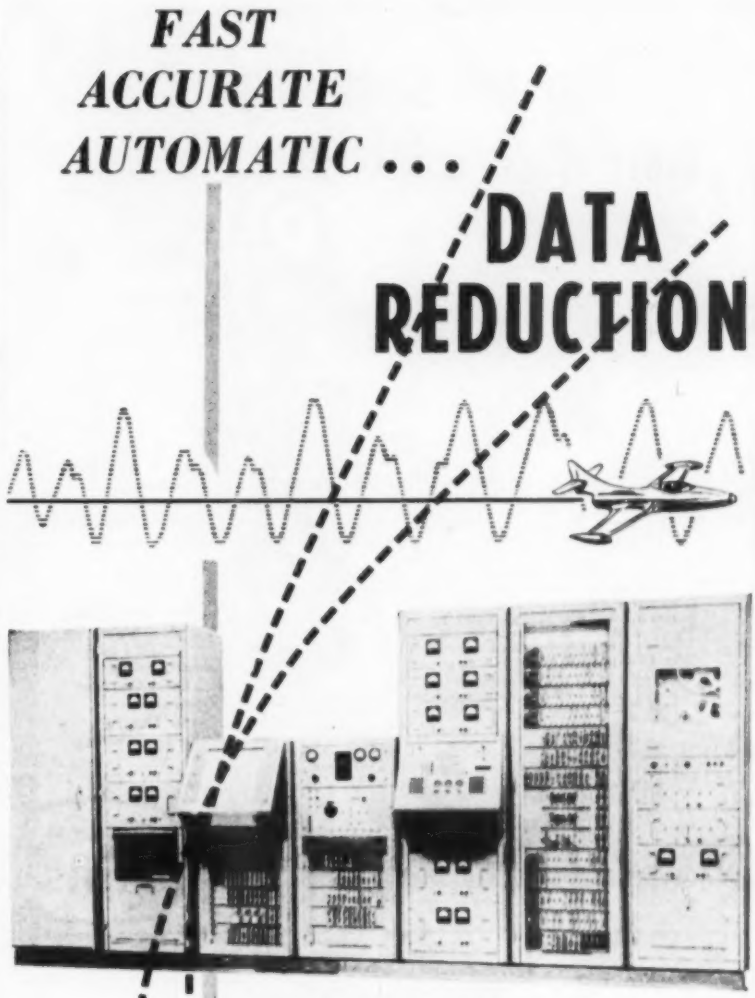
During this critical stage, with the assumed tracking error, the errormeter would not have gone much below the glide path. The exact departure is difficult to estimate since the timing and rate of descent are not known with sufficient precision. However, to show how delicate this point is, the meter would probably have read between zero and 30 ft. below.

Legally, the Pilot was entitled to receive enough height information by which to fly his aircraft safely and on which to base his decisions. This he did not get. On the other hand, if the flight path previous to the "80 ft. high" point is not taken into account, the time interval of the critical phase is so short that no one could blame the Controller for not passing further height data.

The issue is, therefore, was the last steep descent unexpected, or could it have been foreseen from the previous flight path so clearly that the Controller should have concentrated upon the elevation situation? I find this question exceedingly difficult to answer, but on balance, in view of the circumstances, I think the verdict should be that the circumstances were such that it should be classed as a true accident and that the Controller was not to blame.

There can be no excuse for the fact that no warning of closeness to ground or instruction to "maintain altitude" was given between the critical phase and impact. It would not have saved the aircraft, however.

The events leading up to the situation described above were the oscillations of the aircraft about the glide path, which started around 3 n.mi. range. From that point the Controller's elevation messages were too



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"bang-bang" and too infrequent. They did not assist the Pilot as much as they should to establish a stable rate of descent. It can be pleaded that the Controller used normal patter and followed standard procedures. Nevertheless, I believe an experienced controller would have assisted much more.

I must conclude that the talk-down in elevation was poor and because of its negative character contributed towards creating the final critical stage. The Controller is only responsible for passing instructions and information; he is not in control of the aircraft. The ultimate responsibility for the safety of the aircraft and for the decision whether it is safe to descend below the break-off height tests with the Pilot. Consequently, even if the talk-down was poor, it was subject to the overriding judgment of the Pilot, and the Controller cannot be blamed for subsequent events arising from the poor control.

Erratic tracking could have contributed, but there is no evidence whatever upon which to base a judgment. The Controller's evidence implies inaccurate tracking—in fact, if literally true, no tracking at all—after the "80 ft. high" point. I have already rejected this suggestion.

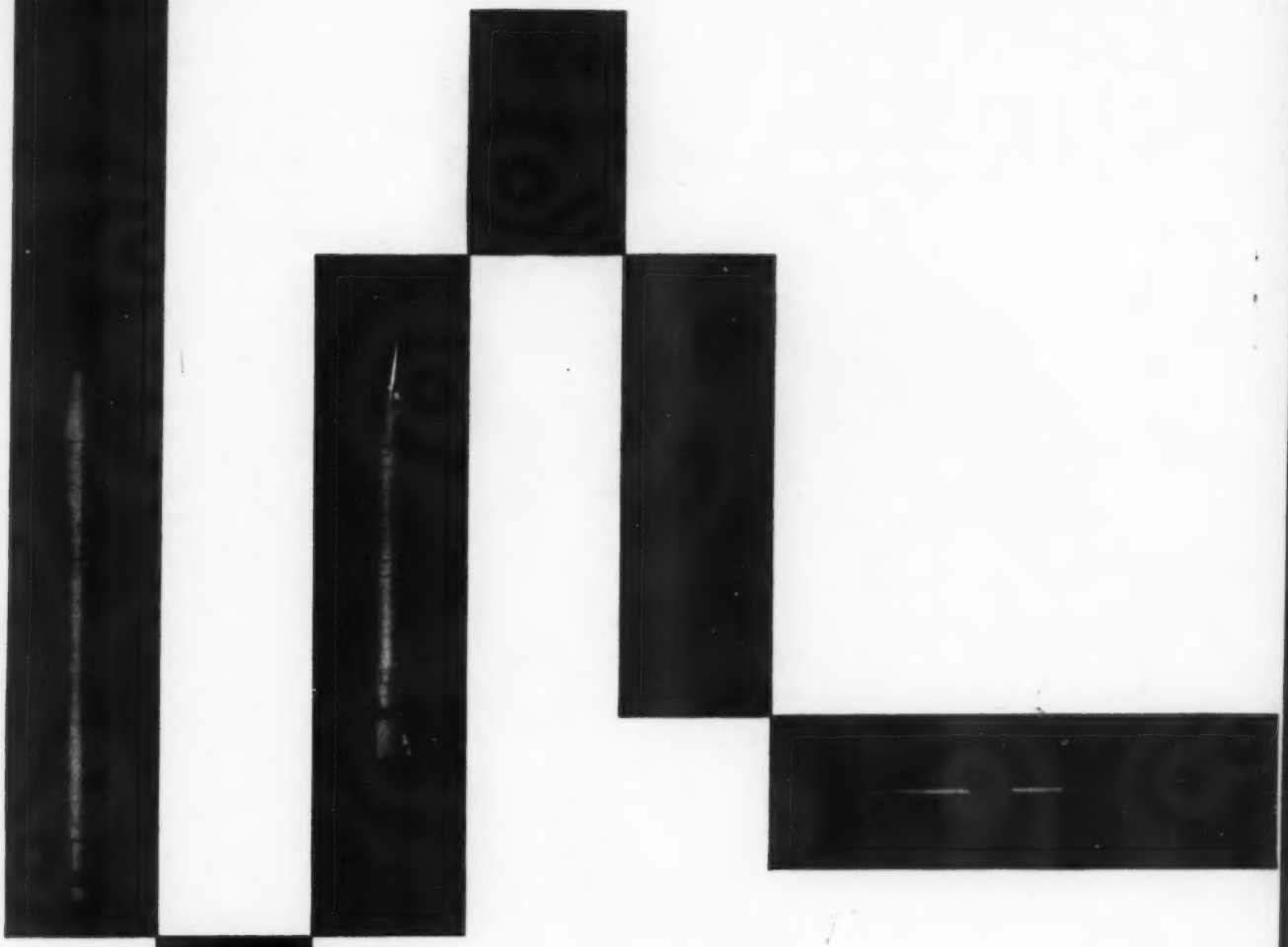
According to M.T.C.A. School of Air Traffic Control, G.C.A. Lecture Notes, a tracker is taught that if a steep climb or dive is seen, the Controller must be advised immediately. Miss Maley, according to her own evidence, does not appear to have recognized the last descent as steep, or does she claim to have warned Controller.

Possibly, if she had done so, it would have been too late. It is possible that with the passage of time and the rationalization of her memories which must have taken place, her remembrance is now at fault, and that her claim that she brought the first descent at two miles to the attention of the Controller really refers to the last steep descent.

It is not possible to produce an explanation which admits all the evidence. I am only too painfully aware that many of the above conclusions are at variance with the evidence given to me, that in some cases they are based not upon scientific deduction but judgment, and that the main argument for them is that they fit together to form a reasonable picture.

Conclusions

- The G.C.A. equipment was correctly set up and calibrated, there is no evidence of malfunctioning or failure.
- The Controller failed to warn the pilot of his closeness to the ground.
- During the last 10 sec. of the approach, the aircraft made a steep descent to ground.
- The cause for this descent was probably due to the build-up of oscillations about the glide path. Poor talkdowns by the Controller contributed to this, but as the approach was subject to the overriding judgment of the Pilot, the Controller was not to blame for events arising from the control.
- The critical phase was the first 4 sec. after the descent steepened, during which no height guidance was given to the Pilot. It is very difficult to pass judgment on this matter, but in view of all the circumstances, I do not think the Controller should be blamed.
- No warning was given during the final 5



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or 6 sec. It should have been, although it would have been too late. Although it cannot be definitely proved, the most likely theory is that the Controller made an error of judgment, concentrating too much upon azimuthal corrections, and paying insufficient attention to the elevation error-meter.

• Human errors are more likely to occur under stress or unusual circumstances. In my opinion, evidence exists to show that all the elements in the G.C.A. servo-chain were strained.

Recommendations

• Human errors can occur at any time, and no legislation can prevent them. All that can be done is to avoid the creation of conditions which make them more likely to occur. It is therefore recommended that military aircraft of advanced design should not normally be allowed to land at Civil Airports under bad weather conditions, unless the breakoff height is very conservative.

• The record of G.C.A. at London Airport is very good, and the system as used at present does not require any radical change. As aircraft speeds increase, however, the controllers will have less time in which to pass instructions. Unnecessary words, such as "you are . . ." "just" "quite" and repetitions in the patter should be avoided. For elevation information, I prefer the use of adjustments to rates of descent, rather than concentrating upon displacement errors. If it is not possible to avoid the latter, more emphasis is required on the necessity to give the pilot displacement data at very short intervals so that he can extract a rate from it without conscious effort.

This is a difficult subject, beset with language difficulties and requiring agreement with A.L.P.A. It is difficult for me to make specific recommendations in this matter. I do know that the responsible officers in M.T.C.A. have the right ideas.

• Visual guidance in azimuth and range is adequate almost as soon as contact is made with the approach lighting pattern, but is not adequate in elevation until quite a low altitude is reached. Height data from G.C.A. should therefore be given to as low a height as possible. Danger of undershoots can be reduced, possibly at the expense of a slight increase in overshoots, by concentrating on elevation data during the last stages of the approach. Serious consideration should be given to a procedure in which elevation data only is provided after the pilot has gone visual, or after the break-off height.

• Split responsibilities should be avoided, if possible. A G.C.A. system in which the Controller observes both sets of displays, eliminating the need for a tracker, is to be preferred. D. of Tels. has developed equipment; it should be put in use soon.

• If G.C.A. is to continue as a primary approach aid (as distinct from a monitor) it is recommended that photographic recording of the displays be carried out.

• Minor recommendation is that the lower edge of the elevation cursor on the present equipments should be serrated as a precaution against it being used for tracking the echo.

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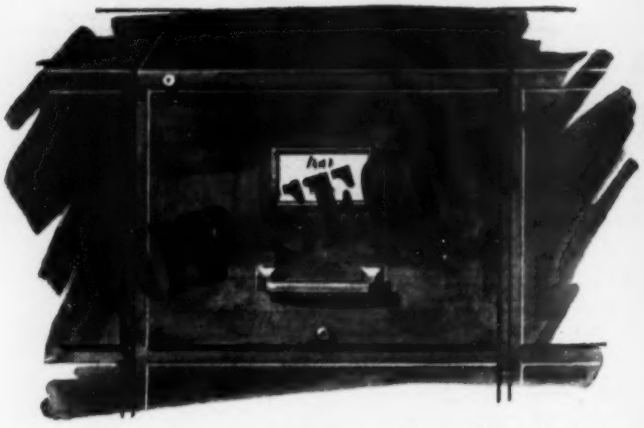

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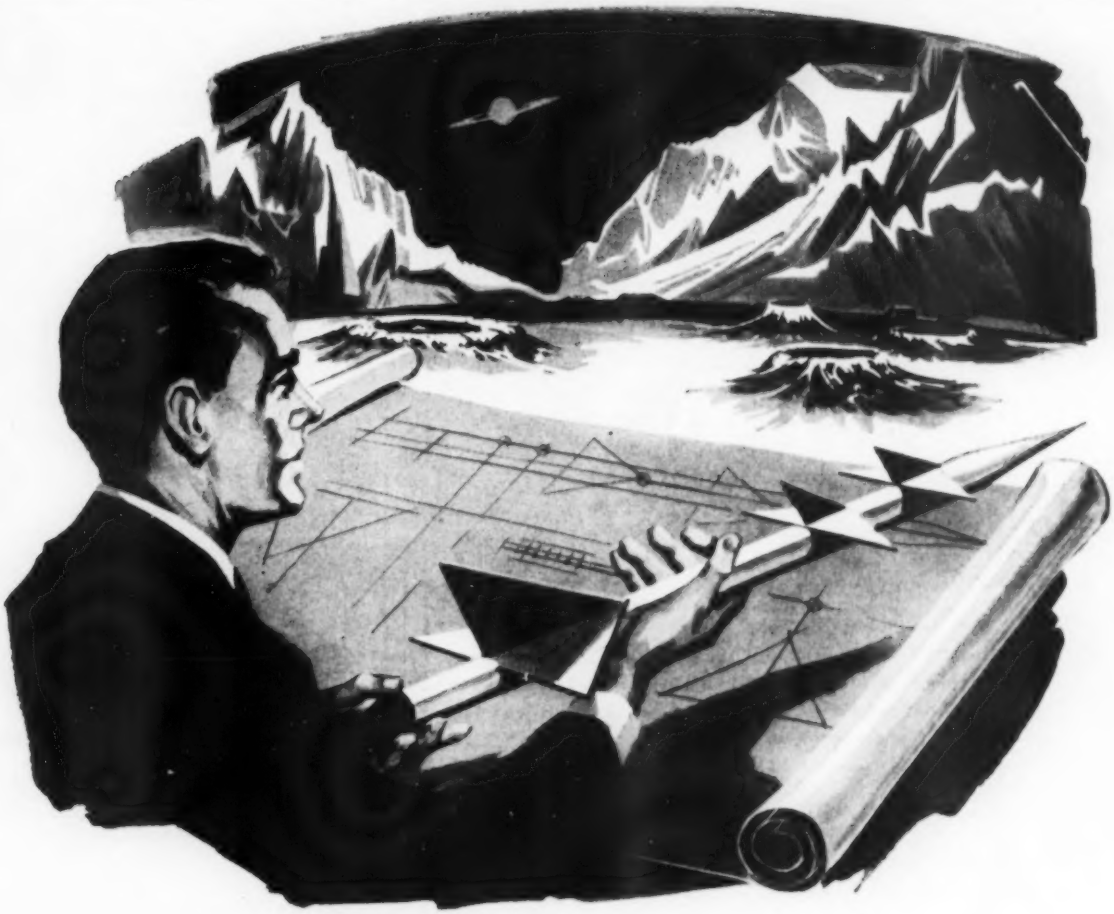

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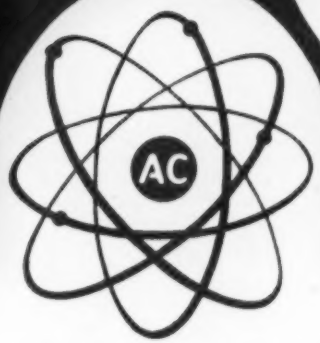

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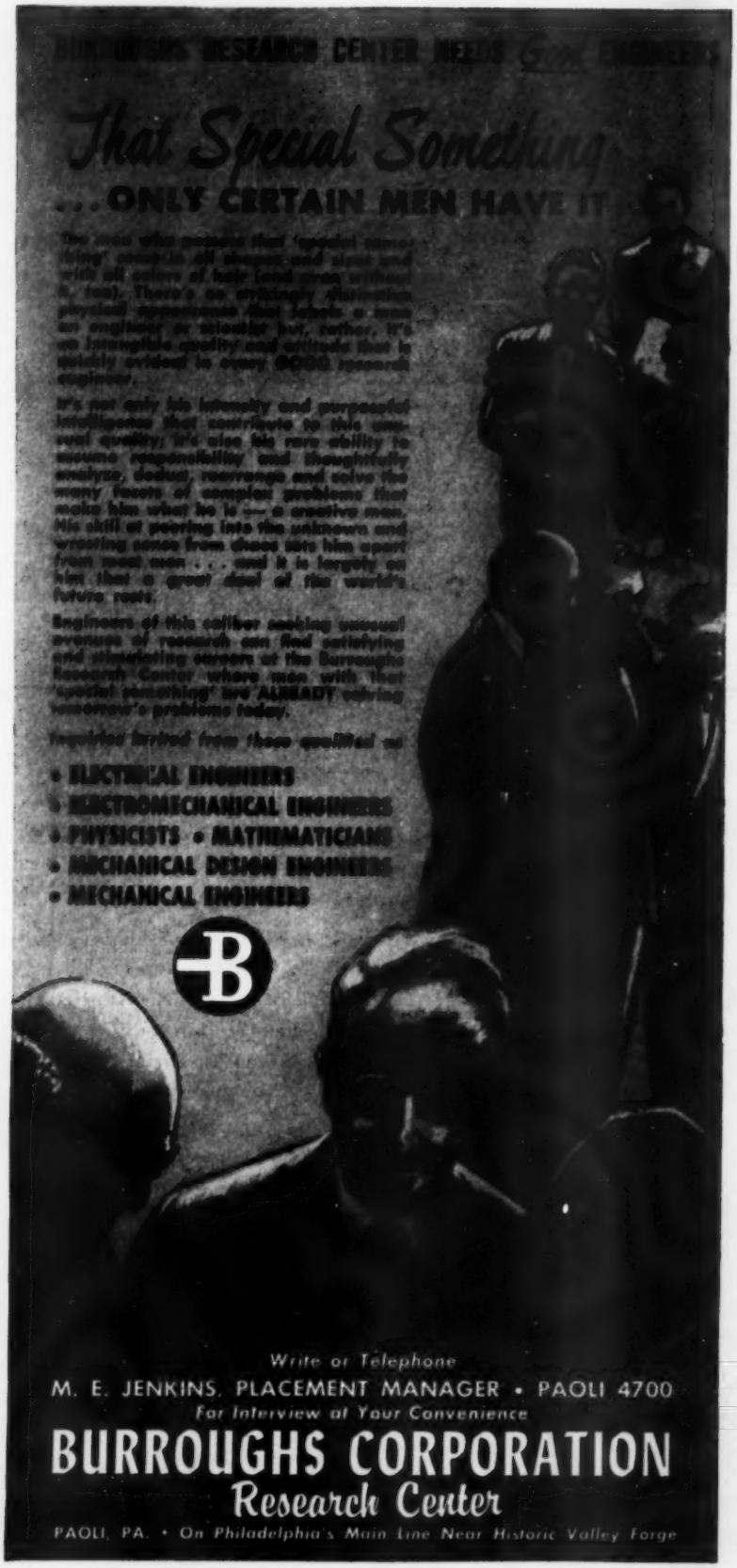
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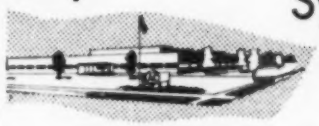

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LETTERS

Air Jordan Stock

In the Dec. 17 issue of AVIATION WEEK you published an article on p. 43 entitled "Lebanon, Turkey and Iraq Reach Agreement on Routes for Airlines." In this article you mentioned that Air Jordan was the only regional airline authorized to resume flights immediately after the disturbances.

You also mentioned that Suleiman Nabulsi, the present Prime Minister of Jordan, is a majority stockholder in Air Jordan. That part of your article pertaining to the resumption of service is perfectly correct. However, I would like to point out that Mr. Nabulsi has no connection with Air Jordan whatsoever. The majority stockholders are Mr. Anwar Nuseibeh and Mr. Abdul Mu'ti El Qutob.

With the above exception I am extremely pleased with your magazine.

R. M. STANLEY
Executive Director
Air Jordan Co. Ltd.
Amman, Jordan

A Pox on Airlines

This letter is in reference to the shortage of prospective pilot personnel for the airlines, which has been discussed in AVIATION WEEK at various time in the past year.

I feel that I can only say to the cry and lament of the airlines regarding this situation, "Isn't that just too bad!"

I recently left the service after seven and one half years of continuous flying experience, during which time I accumulated 2,300 hours as a fighter pilot, three-fourths of that time as a jet fighter pilot. As every fighter pilot knows, every minute spent in the cockpit is command decision time—you are the pilot, co-pilot, navigator, bombardier, radio man, etc.—none of it can be attributed to coffee time or sack time. Every decision made is yours, right or wrong. Consequently, I am sure you can understand my feeling of confidence on leaving the Service that my experience could be of some value to the airlines, what with their terrible need for pilot personnel. So, armed with my log book, necessary CAA licenses, and college degree, I applied for a job. Can you imagine my shock and surprise to learn that I was not acceptable for consideration, due to the fact that I am only 5 ft. 6 in. tall! And yet, the applicant next to me, who was 1 in. taller than I, was perfectly acceptable, even though his total flight time was all of 400 hours in a Piper Cub, and who, by his own admission, was a little vague about the difference between VFR and IFR.

While the shock of all this was soaking in, my mind was filled with sights of many short pilots such as myself in the service, flying BIG AIRPLANES, of my own many jet instrument approaches (where a slight movement of the stick will vary your rate of descent by 2,000-5,000 feet per minute). The reason for my rejection was soon apparent, however, with the remarks from the interviewer, "You realize that it is just for appearance's sake, for as you know, the rudder pedals are adjustable."

I must admit the last remark was the killing blow, and I went away a broken man. It was quite evident that past proven ability and experience in aviation was of little or no importance, but if you can meet certain height measurements, so as to present a desired appearance, then you can be properly trained (I have yet to see a flight officer on a commercial airline trip).

Perhaps I could be termed a bit cynical, but my reaction remains the same—a pox on all airlines, and may they wither and die from lack of pilot personnel.

MILITARY PILOT

Aviation Week welcomes the opinion of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42 St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

For Service Rendered

I have just finished your editorial in the Feb. 11 issue of AVIATION WEEK. You are to be commended on the service you are rendering the country through your writing. Certainly, no one who has any real knowledge of the subject of air power in the United States can deny that the American people should be dissatisfied with our technological progress—not that it isn't very substantial.

But when the defense of the nation is at stake nothing but our very best effort should be acceptable, and nothing but our very best effort is going to keep us ahead of the competition.

I feel that I speak for a great many people who, like myself, served in the Air Force both during World War II and afterward. I am concerned about the fairly general belief that the amount of money we spend is going to make the difference between satisfactory results and unsatisfactory progress. I feel that an equally important feature is the manner in which money made available by Congress is being handled.

My best wishes to you, and good luck in your efforts in the interest of American air power.

GEORGE E. SCHAETZEL

Demotion

We read with interest your story, "Traffic Control Clarification Needed Before Advent of SAGE," in the 4 Feb. 1957 edition of AVIATION WEEK (p. 44) which reported in part on the air traffic control discussions that took place at the recent meeting of the Institute of Aeronautical Sciences in New York City.

The article was essentially accurate but one detail should be further clarified. The paper discussing joint civil/military traffic control problems was indeed read by Col. S. A. Mundell, Chief of this Division, but unfortunately you demoted him. He is a colonel, not a lieutenant colonel, with a serial number of 657A which indicates a rather senior colonel in the Air Force Register.

Incidentally, Col. Mundell's experience in air traffic control includes not only research and development but extensive operational experience, his latest being that of Commander, 1800th Airways and Air Communications Service Wing at Tinker Air Force Base, Okla.

AVIATION WEEK is read extensively in this office by all operational and engineering personnel as it provides the best source of general aviation news available. Keep up the good work.

GEORGE B. JOHNSON
Asst. Chief, Air Traffic Control and Navigation Division
Directorate of Systems Management
Air Research & Development Command
Wright-Patterson AFB, Ohio

Bureau of the Books

I trust I am not too late in commenting on the letter "Technical Books" in the Dec. 31, 1956 issue (p. 86).

In it, the writer proposes the publication of aeronautical engineering books "rigorously accurate and thorough" available "at low cost, with the authors, editors, and publishers protected against loss by the government."

No book exists, he says, on landing gear design practices. Such a book wouldn't be a best seller, he says, and its economic life would be short. We need such books, he explains, because "plenty of intelligent, industrious and ingenious Americans . . . are separated from a productive career in aeronautical engineering only by their lack of specialized aeronautical know-how" that could be provided by these books.

Well, I'm an intelligent, industrious, ingenious American and I know an opportunity when I see one. And furthermore, I'd hate to see anyone separated from a productive career. I'm going to write my Congressman and get a little old bureau set up. BATS we'll call it—Bureau of Aeronautical Textbook Subsidies—and I'll be chairman and *we'll* have a *long* economic life.

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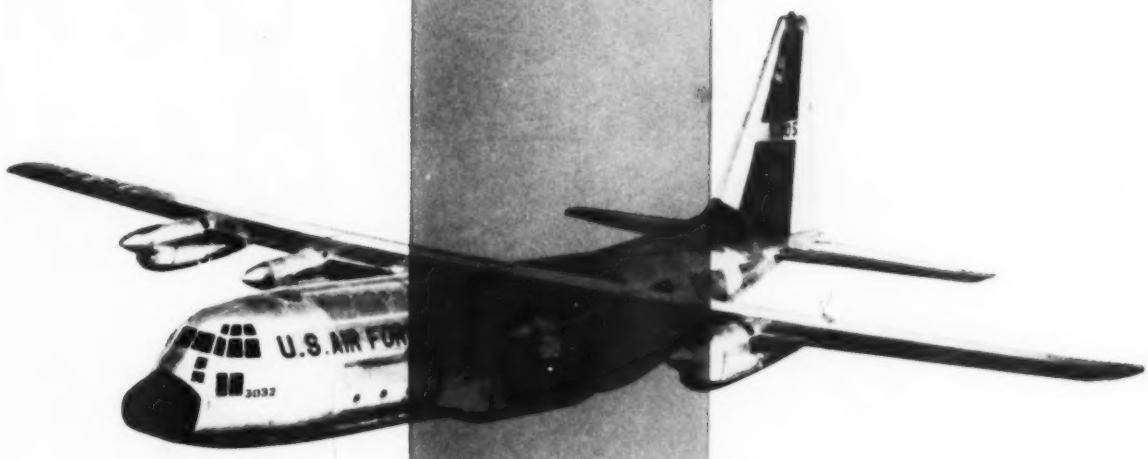
All in all, I think we'll set quite a few feet on the upward path. Some day we can all look back, gently holding a copy of "Design Practices, Land Gear, Aircraft" (First Edition 5,000,000, counting 4,997,001 stored in BATS Warehouse #2, Pittsburgh) and smile, knowing we don't need landing gear any more. We will have gone too far to ever come back.

DANIEL B. DOWNER
San Marino, Calif.

for TAC's new C-130 Hercules...



Flight Control System—by Sperry

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Since the C-130 works at different altitudes for its various missions—from cargo-drop level to over 35,000 feet—its flight control system must provide precise, automatic control over a wide range of flight conditions. More than equal to the job is Sperry's E-4 system which—for the first time in an Air Force plane—is linked to a Sperry Radio Beam Coupler.

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GEORGE JUDE, Director, Flight Control Engineering of our Aeronautical Equipment Division. Serving Sperry for 18 years, he won the 1956 Lawrence B. Sperry Award "for significant contribution to the advancement of precision automatic flight control and safe all-weather flight."

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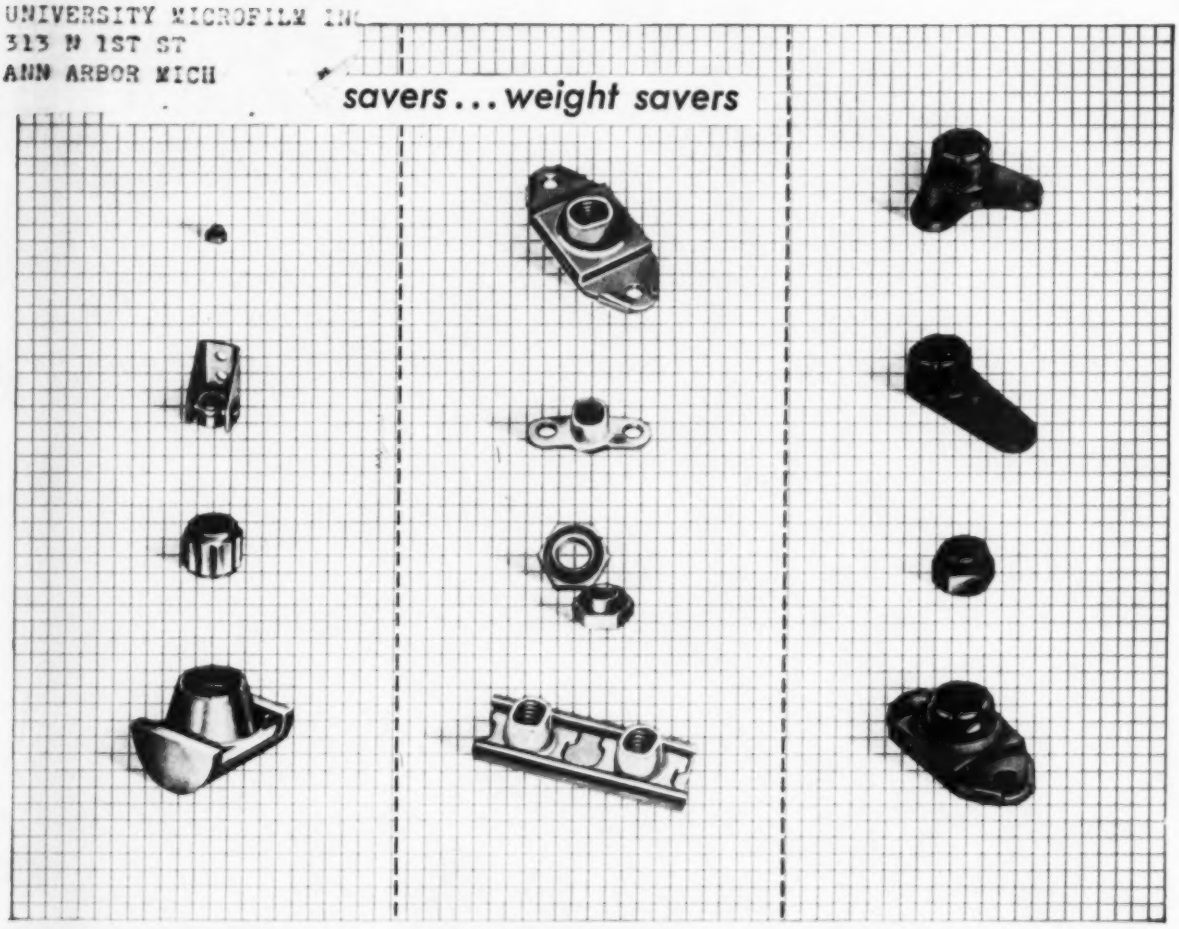

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